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Evolving Research for Stormwater Management

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Evolving Research for Stormwater Management

James Houle, UNH Stormwater Center

Providing Data to Protect Water Quality Since 2004

Hydrodynamic Separator

Isolator Row

Subsurface Infiltration

Filter Unit

Porous Asphalt

Pervious Concrete

Retention Pond

Stone Swale

Veg Swale

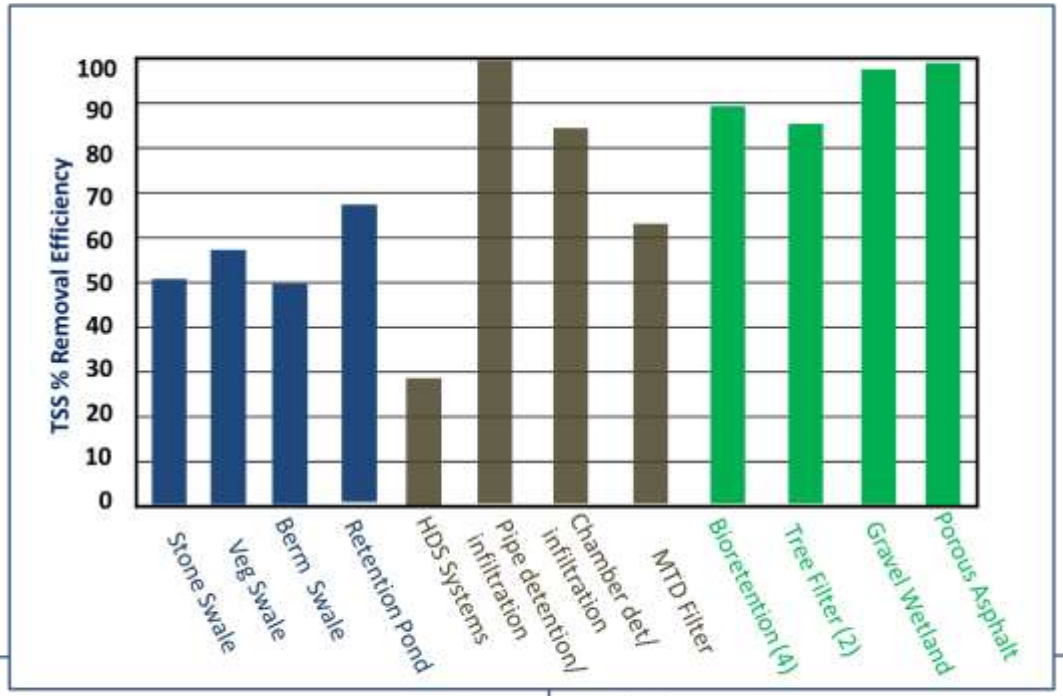
Gravel Wetland

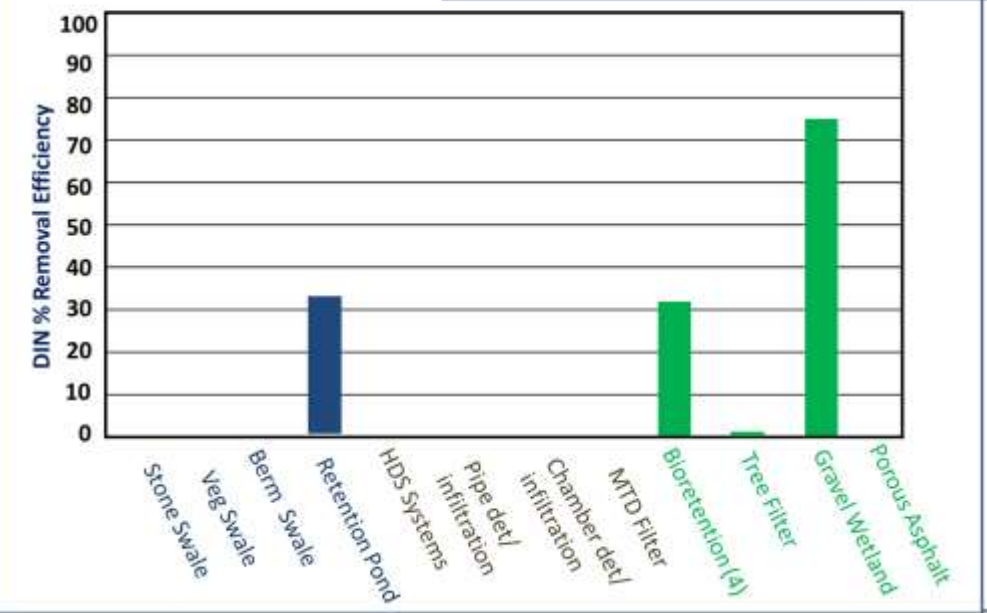
Sand Filter

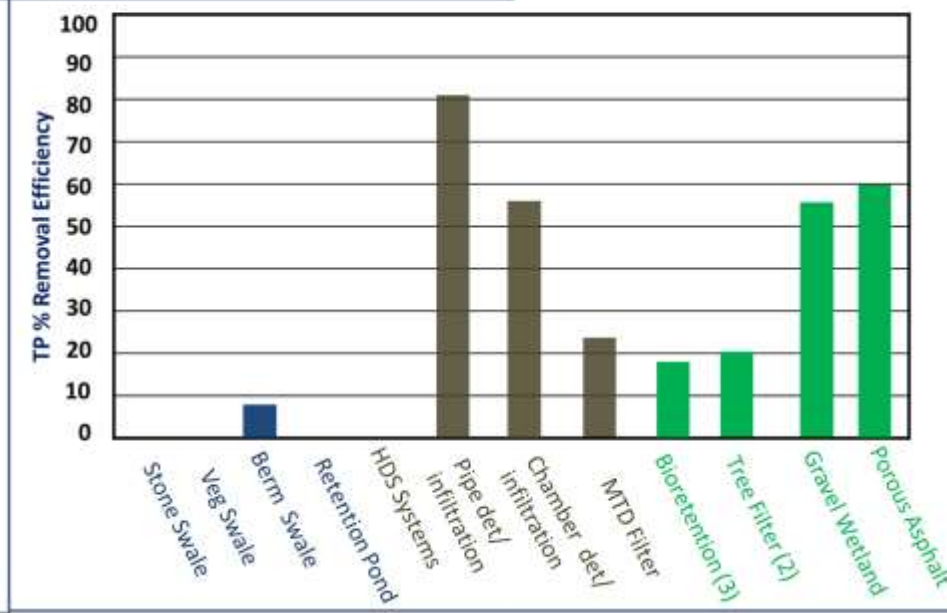
Bioretention Unit

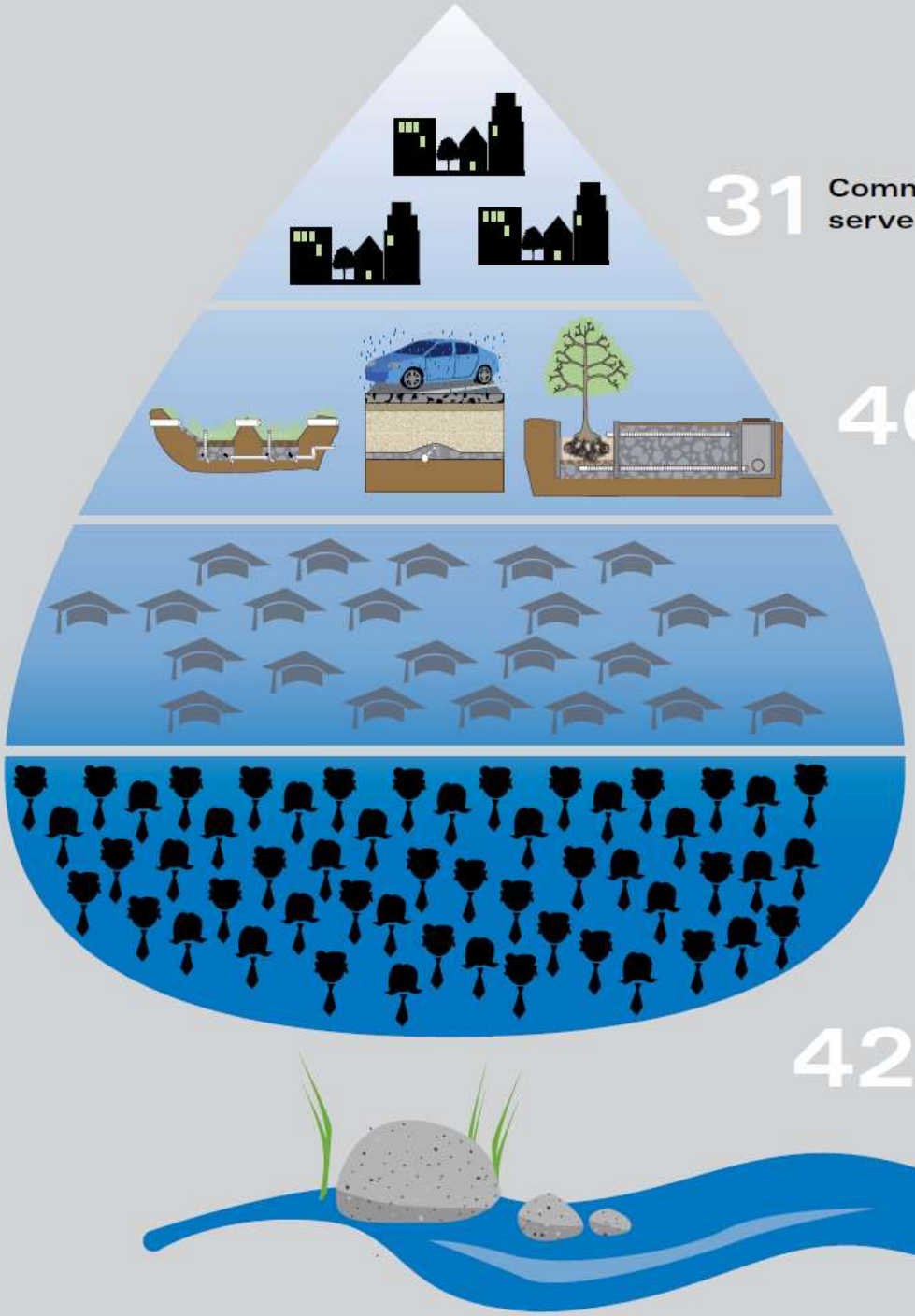
Tree Filter

Common Pollutant RE's









31 Communities and organizations served in 16 states and countries

40 Stormwater treatment systems tested

2,686 Students educated

3,680 Professionals trained

42 Bodies of water protected

Decadal Reflections: Cart Before the Horse

The expression cart before the horse is an idiom or proverb used to suggest something is done contrary to a conventional or culturally expected order or relationship.

Cuyahoga inlet to Lake Erie circa 1920

"Cuyahoga mouth". Licensed under Public Domain via Commons - https://commons.wikimedia.org/wiki/File:Cuyahoga_mouth.jpg#/media/File:Cuyahoga_mouth.jpg

- Cuyahoga caught fire at least 13 times!
- First, 1868 – Last, 1969
- 5 deaths 1912
- Largest was in 1952

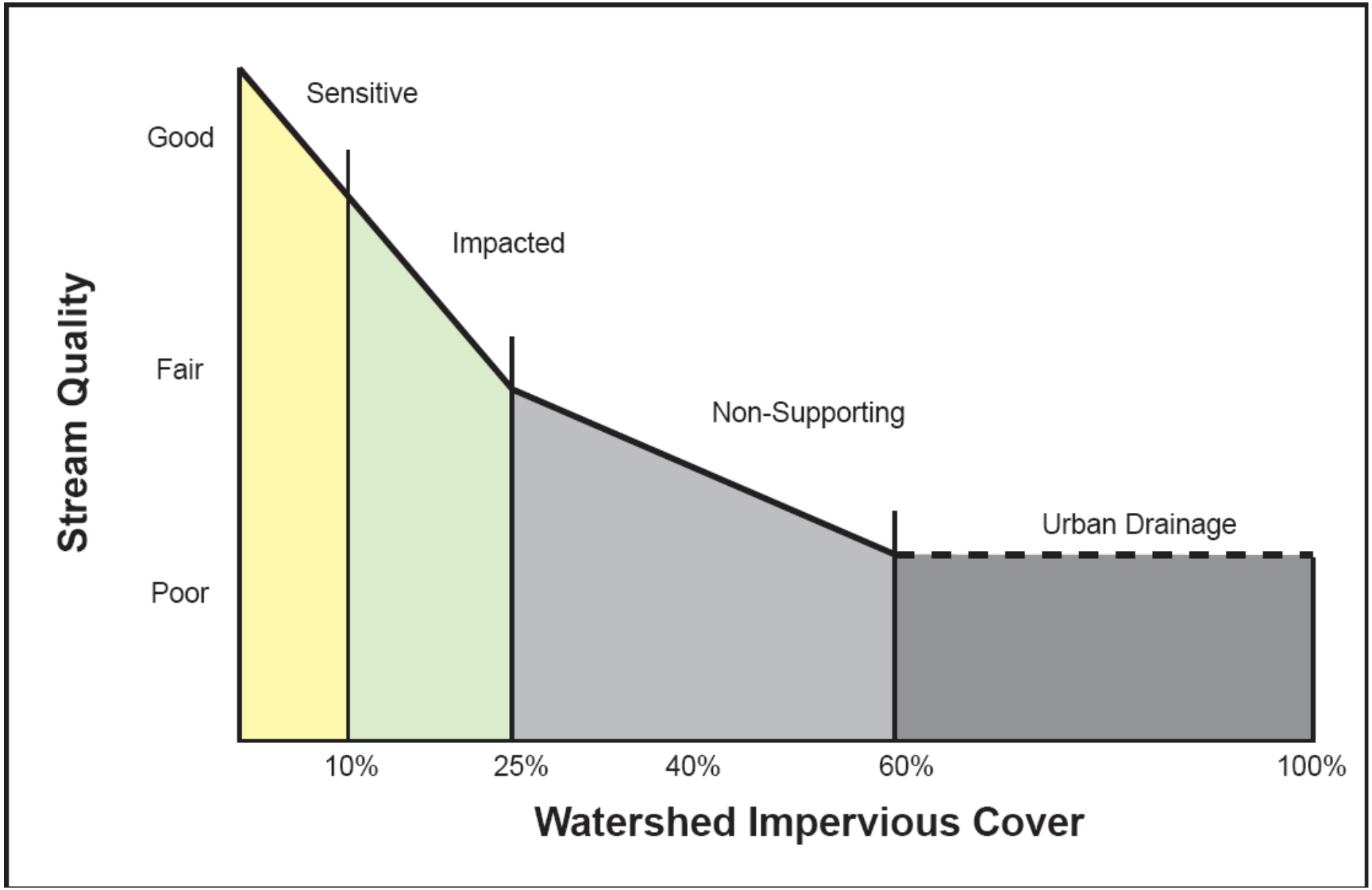
Cuyahoga River Fire Nov. 3, 1952. Courtesy of Cleveland Press Collection at Cleveland State University Library.

June 22, 1969: Umm, the Cuyahoga River's on Fire … Again

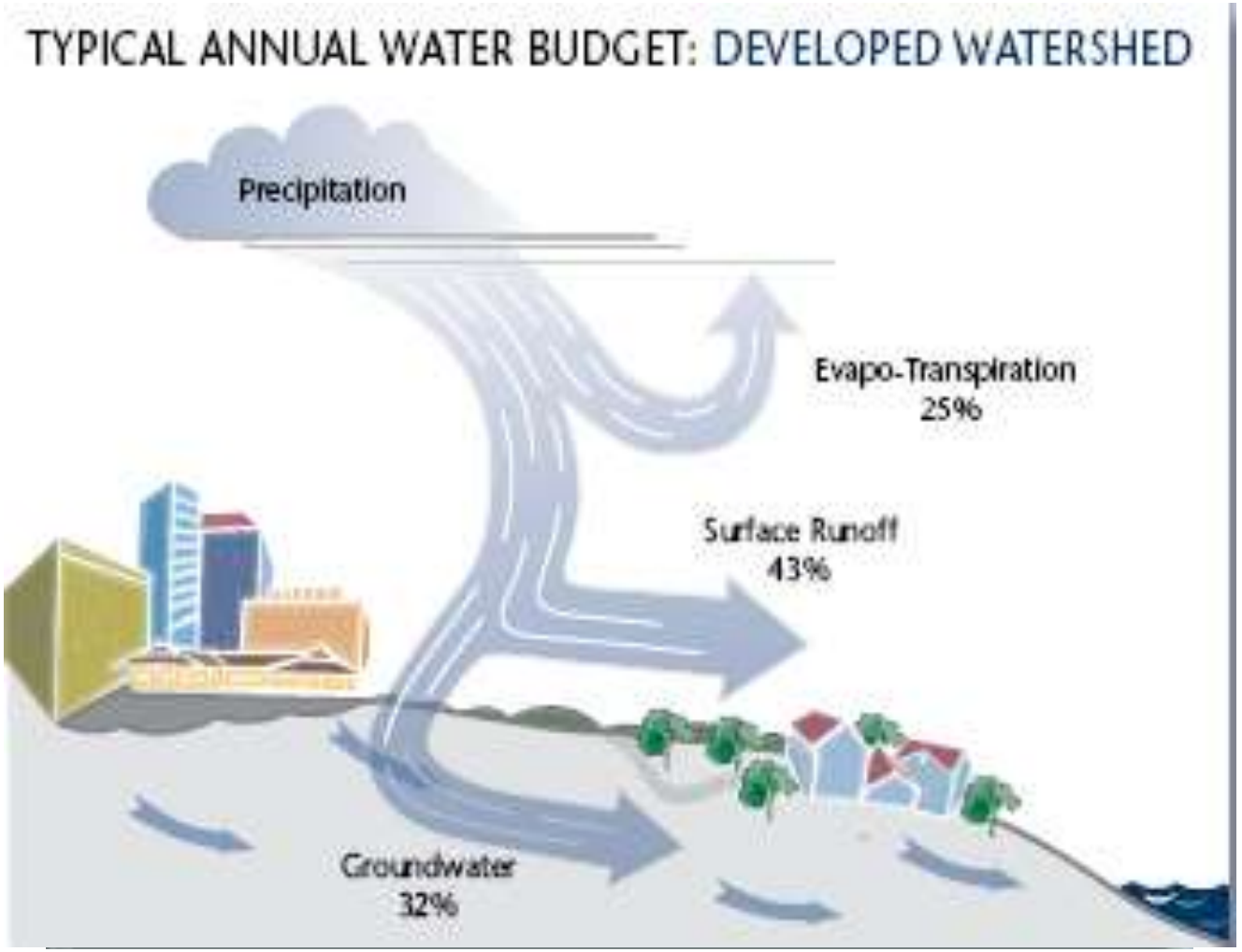
Modern Day Equivalent: Priorities and Water Quality

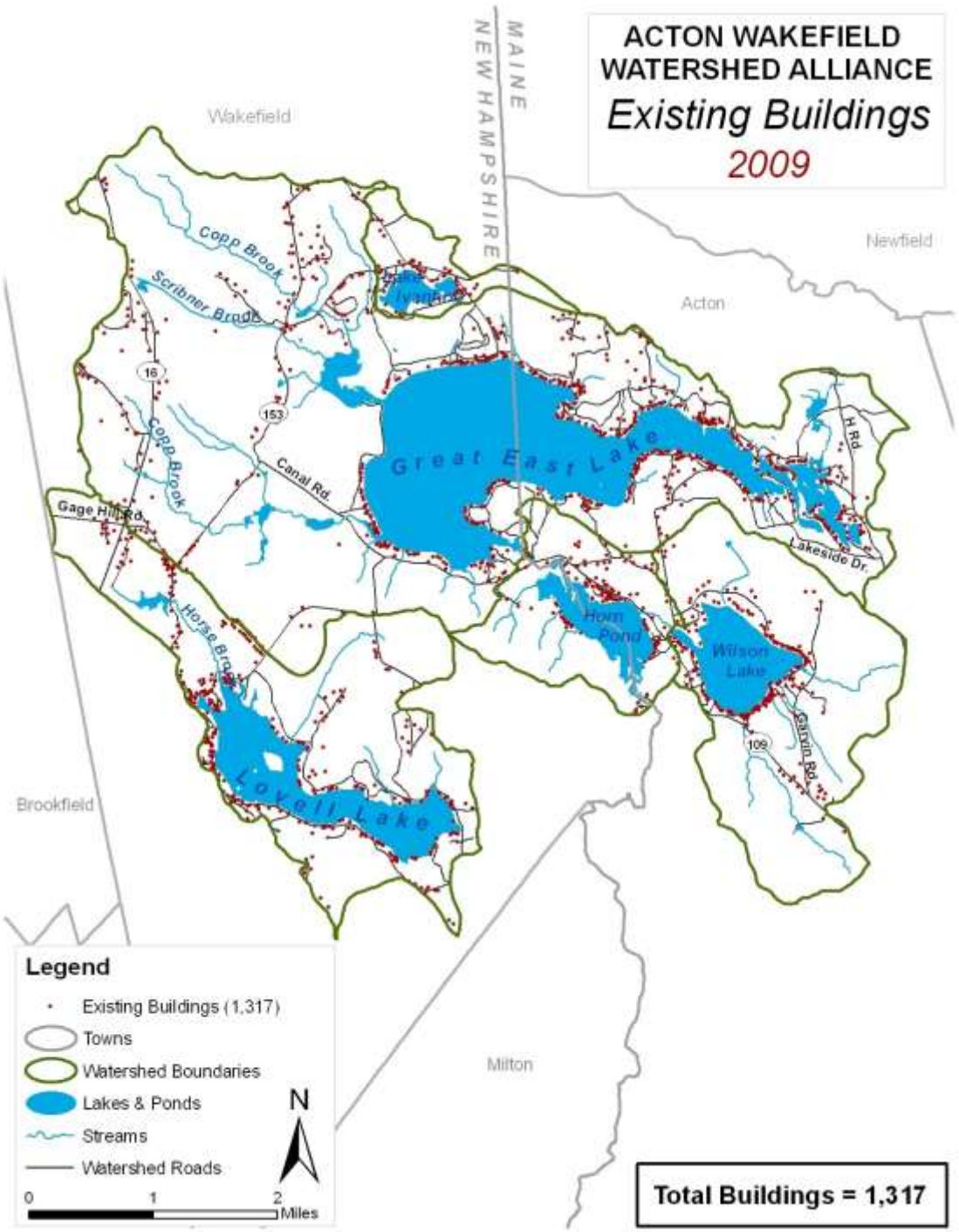
NPS is Part of the Problem and managing it is part of the solution

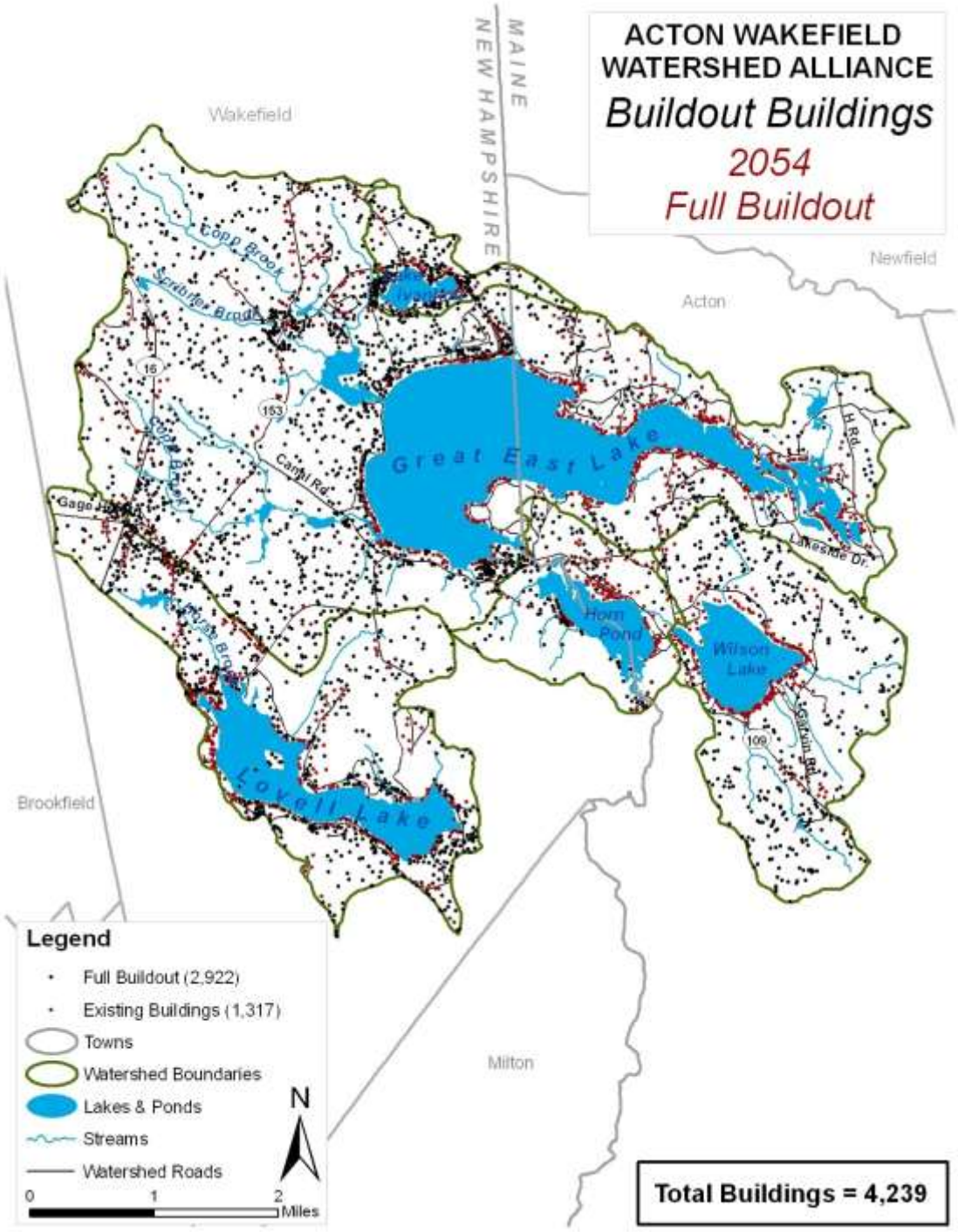
Impact of Impervious Cover



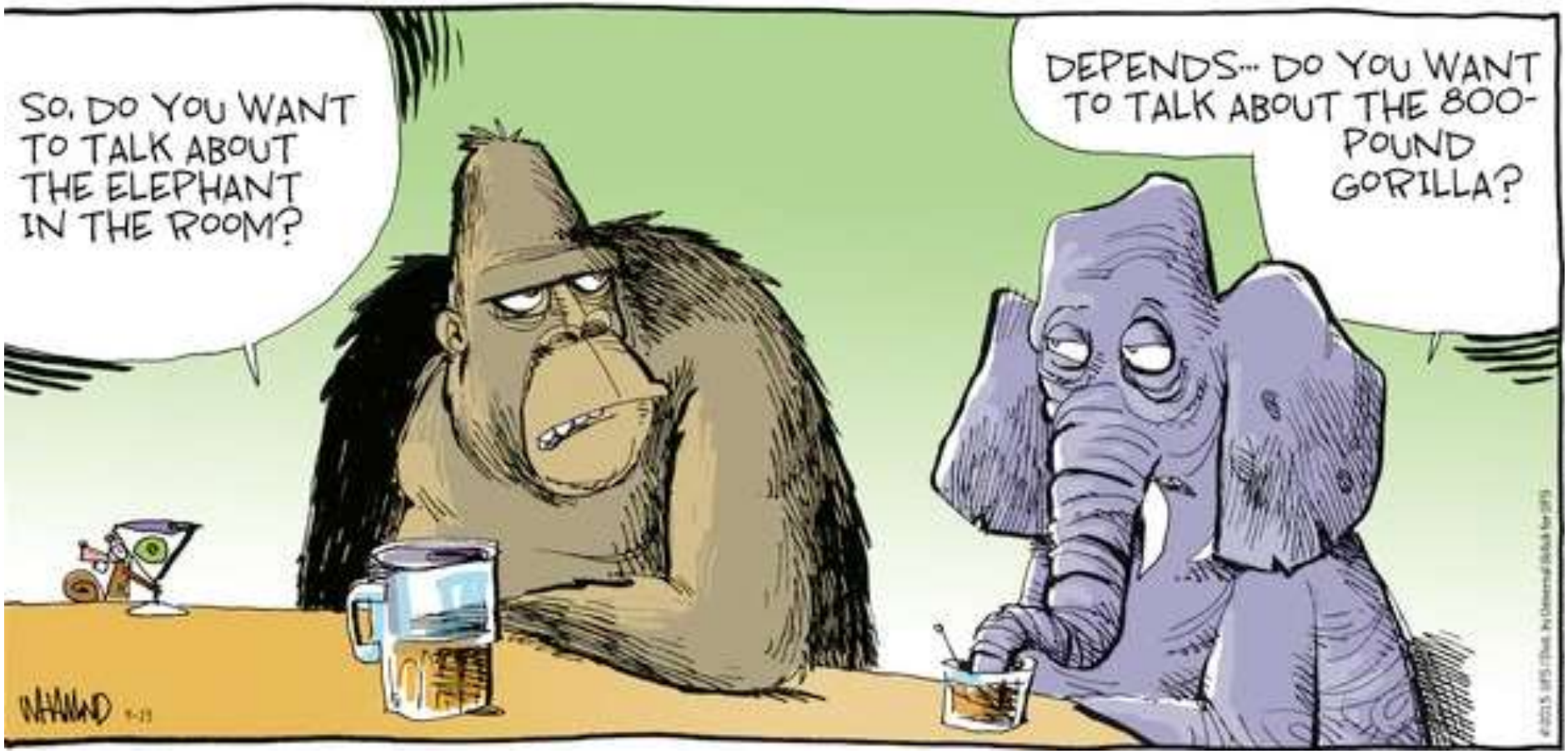
Water Cycle


TYPICAL ANNUAL WATER BUDGET: DEVELOPED WATERSHED
Precipitation
Evapo-Transpiration
25%
Surface Runoff
43%
Groundwater
32%


ACTON WAKEFIELD
WATERSHED ALLIANCE
Existing Buildings
2009
MAINE
NEW HAMPSHIRE
Wakefield
Newfield
Acton
Brookfield
Milton
Copp Brook
Scribner Brook
Tributary
16
153
Copp Brook
Canal Rd.
Gage Hill Rd.
Great East Lake
H Rd.
Lakeside Dr.
Horse Brook
Horn Pond
Wilson Lake
109
Garvin Rd.
Lovell Lake
Legend
Existing Buildings (1,317)
Towns
Watershed Boundaries
Lakes & Ponds
Streams
Watershed Roads
N
0
1
2
Miles
Total Buildings = 1,317

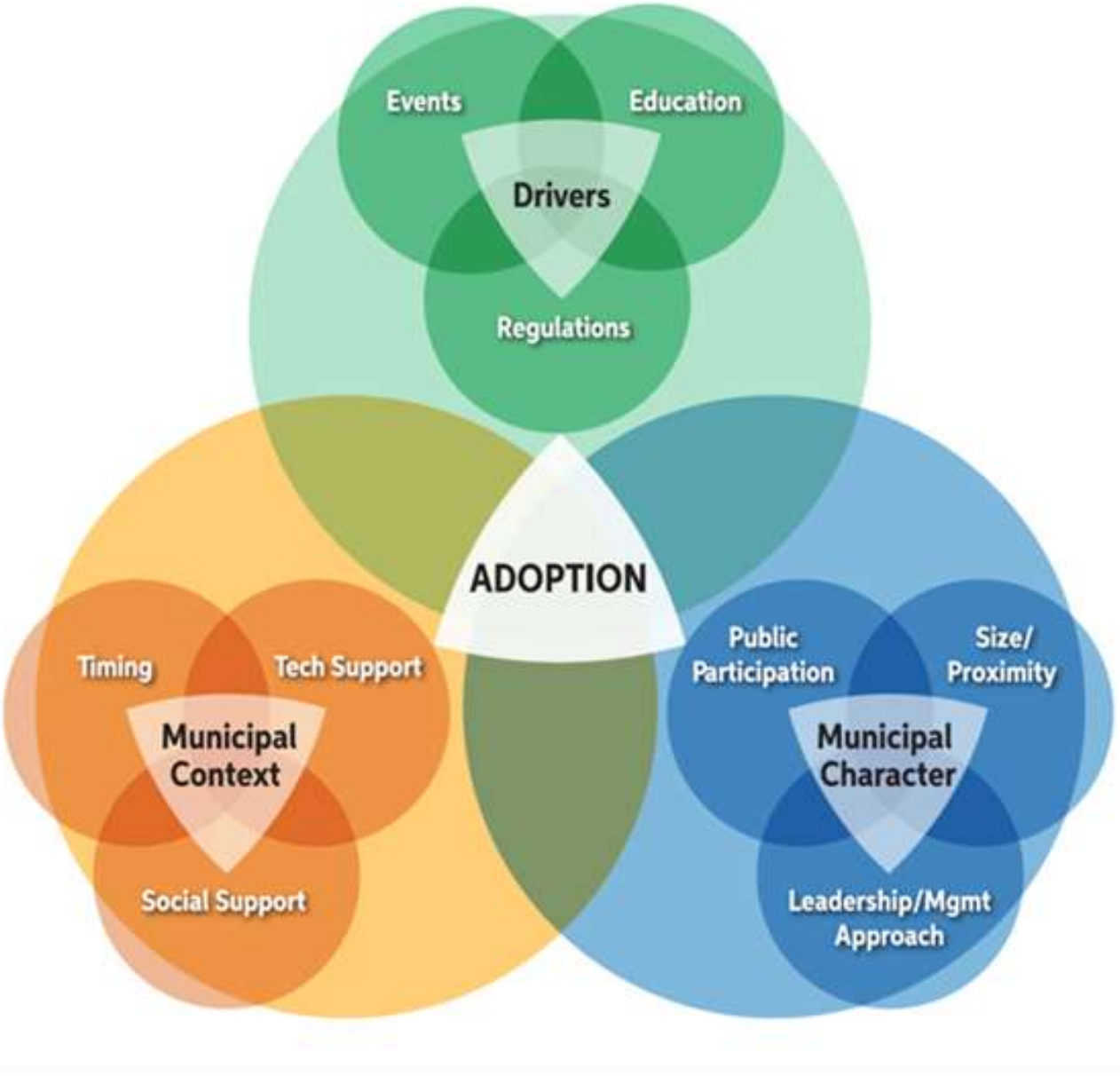

ACTON WAKEFIELD
WATERSHED ALLIANCE
Buildout Buildings
2054
Full Buildout
MAINE
NEW HAMPSHIRE
Wakefield
Newfield
Acton
Brookfield
Milton
Copp Brook
Great East Lake
Horn Pond
Wilson Lake
Lovell Lake
Lakeside Dr.
Goodwin Rd.
Legend
Full Buildout (2,922)
Existing Buildings (1,317)
Towns
Watershed Boundaries
Lakes & Ponds
Streams
Watershed Roads
N
0
1
2
Miles
Total Buildings = 4,239

Yes, climate change gives us pause to think, but IC is the 800-pound gorilla

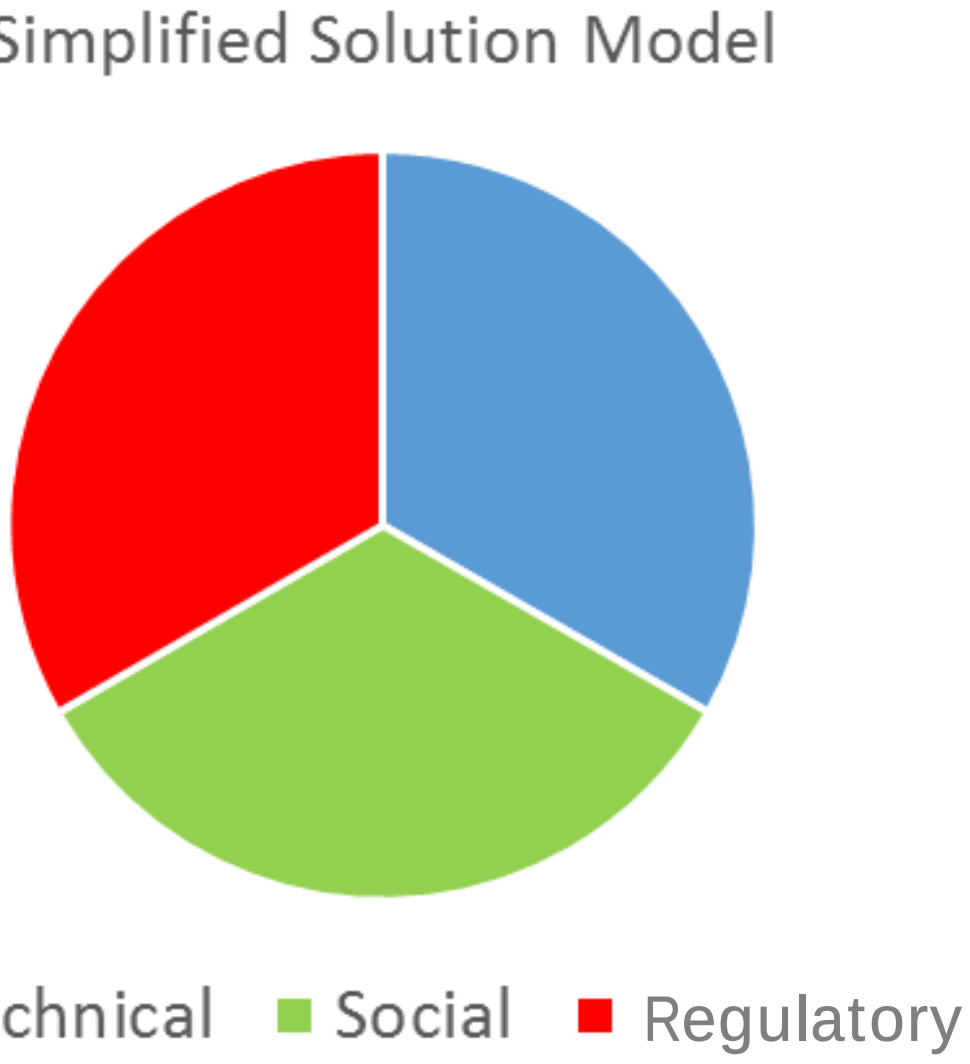


If we know what the problem is…
…and science informs us what we can do…
…Then how are we doing on implementation?

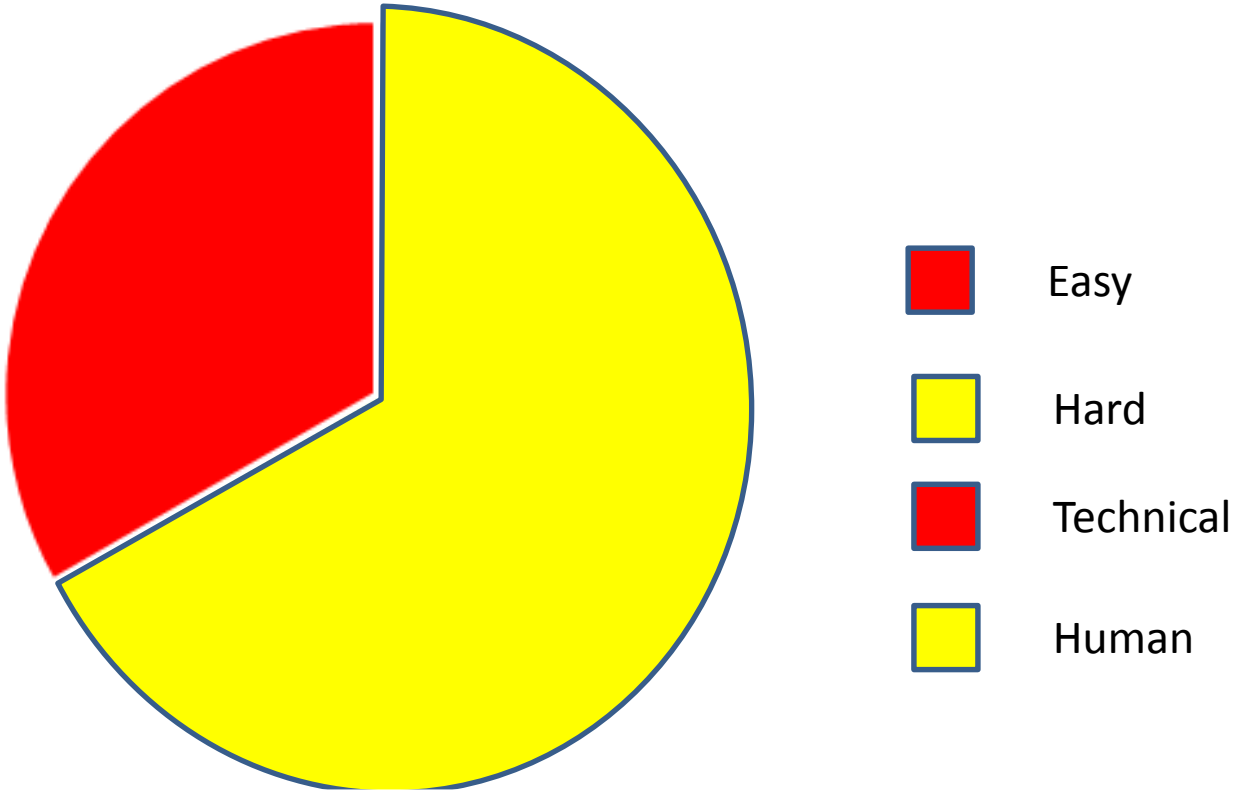
Conceptual Model Factors Influencing Adoption



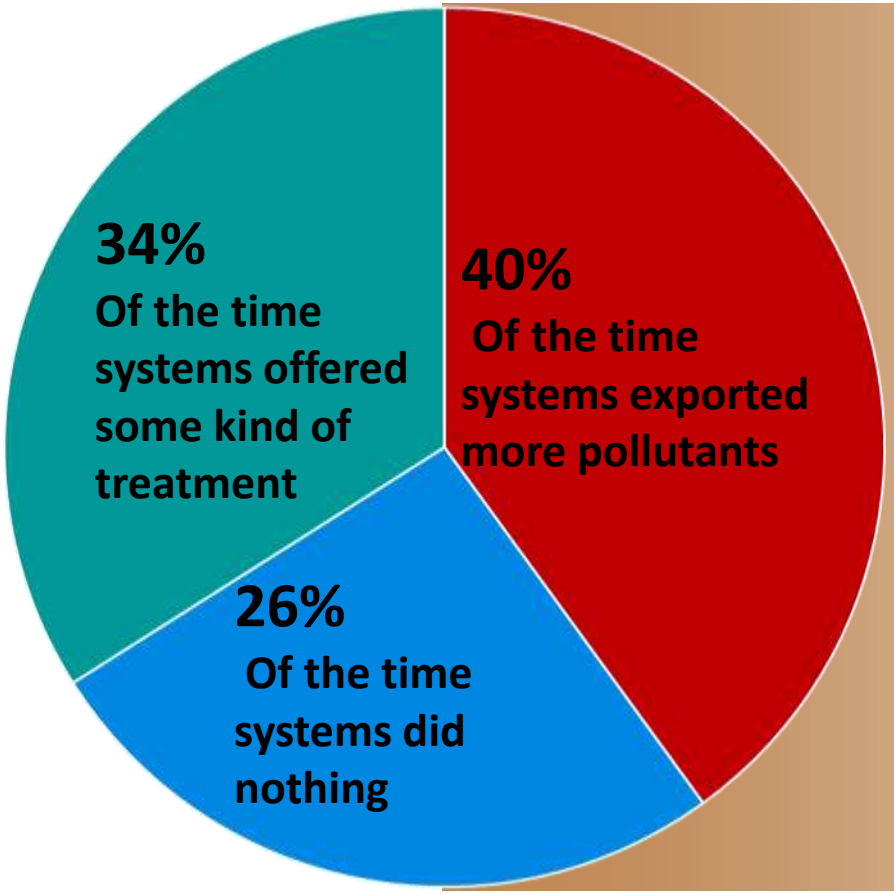
Solutions



Simplified Solution Model



Technical



Systems failed 2/3 of the time!

Conventional Stormwater Management

- Retention/Detention---flood control
- Conveyance---swales, catch basins, gutters
- No recharge or water quality components

Conventional System Design

Shortcomings of Traditional Stormwater Management

1. Inadequate pollutant removal
2. Inadequate cooling
3. Inadequate stream channel protection
4. Lack of maintenance
5. Ready-fire-aim

Low Impact Development

Modeling designs after natural systems

Low Impact Development

LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product.

Goal: ***HYDROLOGIC TRANSPARENCY FOR DEVELOPMENT***

How Do They Really Work?
43 in rainfall event in 3 minutes!

LID Designs

- Infiltration
- Sand filters
- Bioretention
- Tree Filter
- Subsurface Gravel Wetland
- Pervious Pavements
- Ecoroof

School Street School, Rochester NH

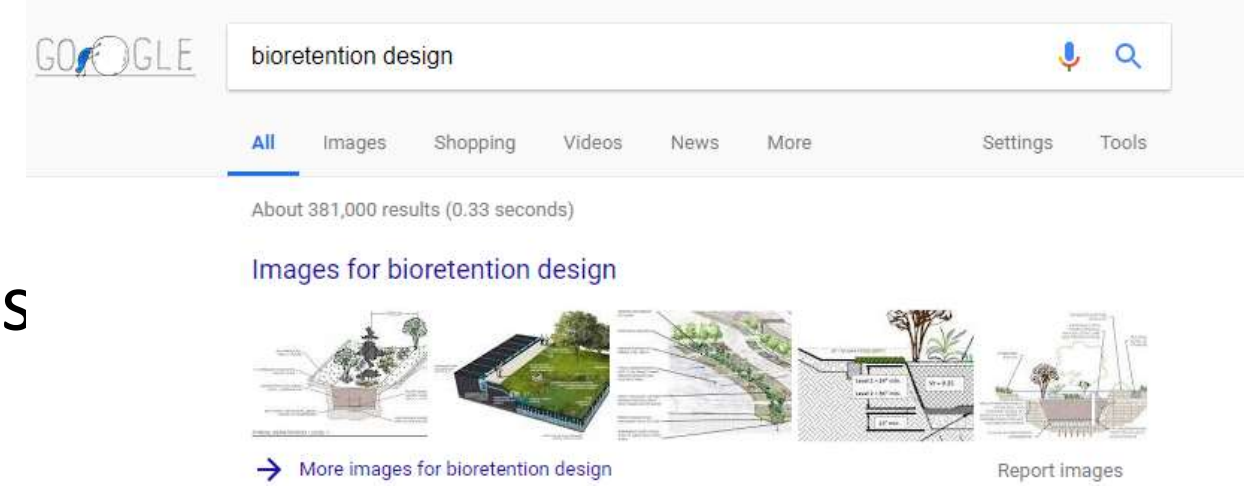
Portsmouth NH

Horne Street School, Dover NH

Durham innovative bioretention system, Durham, NH.

“Bioretention Design”

- 381,000 results



Terminology

- Bioretention – Holds WQV. Typically has underdrain, high flow bypass, and hydraulic design
- Rain garden – Holds WQV or less. Commonly for very small watersheds (residential), often do not have an underdrain
- Tree filter – Very little storage. Urban installations include high rate media designed on WQF. For Very small drainage areas, underdrain to storm sewer

System Design

- Above-ground volume
- Inlet
- Layers
  - Media
  - thicknesses
- Surface area
  - Dynamic sizing
- Hydraulic structures
  - Media hydraulic conductivity
  - Secondary
  - Emergency/flood

Bioretention Soil Mix – Many Variations

- Sand: 50-85%
- Wood chips/shredded wood: 20%
- Compost: 10 – 20% **{no compost due to P issue}**
- Soil: 10-30%

- Preferably fines less than 5% (some specs still want 8 – 12%) UNHSC prefers <2%
- 5.5 < pH < 6.5
- Phosphorus index 10-30
- CEC > 10

UNHSC Bio Mix

- 50% Sand,
- 30% loam
- 20% wood chips

Sieve #	Sieve Size in (mm)		% Passing
4	0.187	(4.76)	100
10	0.079	(2)	95
40	0.017	(0.42)	40 - 15
200	0.003	(0.075)	10 - 20
<200	Pan		0 - 5

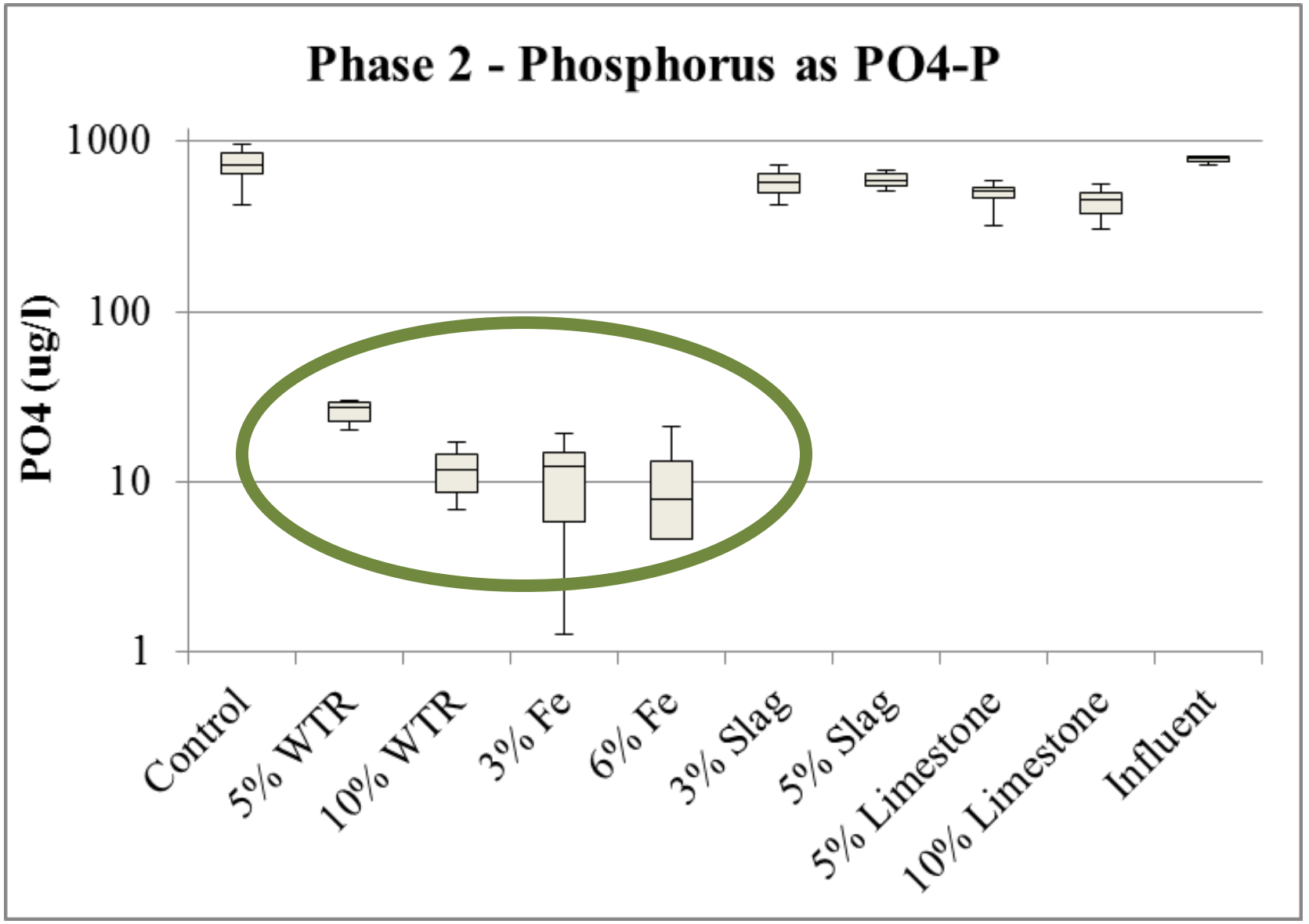
Soil Mix Amendments

- Zero Valent Iron
- Alum sludge
- Limestone sand
- Slag
- Expanded Shale
- Zeolite
- Proprietary

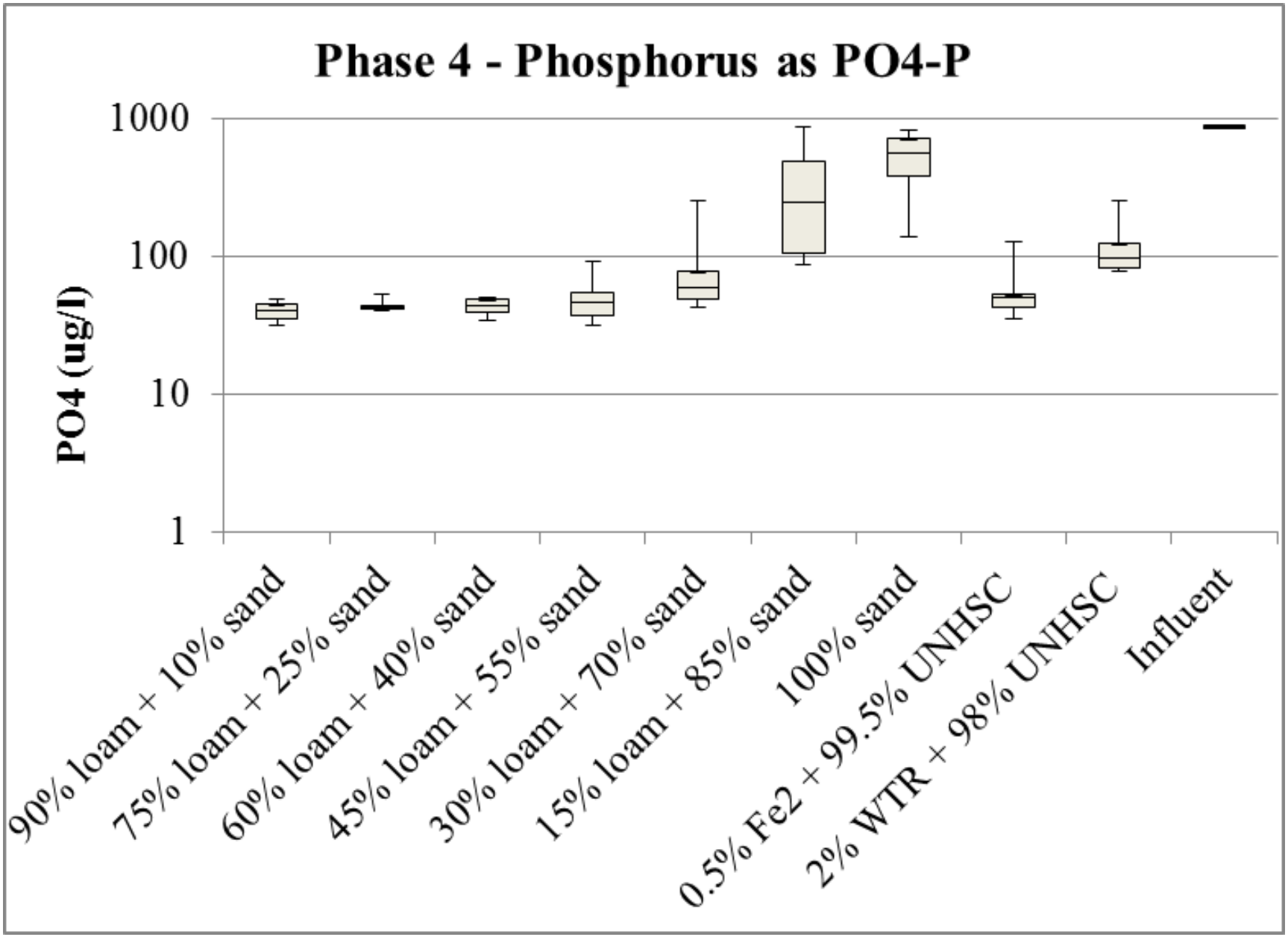
Column Study of Nutrient Removal

- Amendments for Phosphorus
  - Alum sludge
  - Zero valent iron
  - Limestone sand
  - Electric blast furnace slag
- Internal storage volume for nitrogen
- Effect of compost

Phosphorus Results



Optimization Results

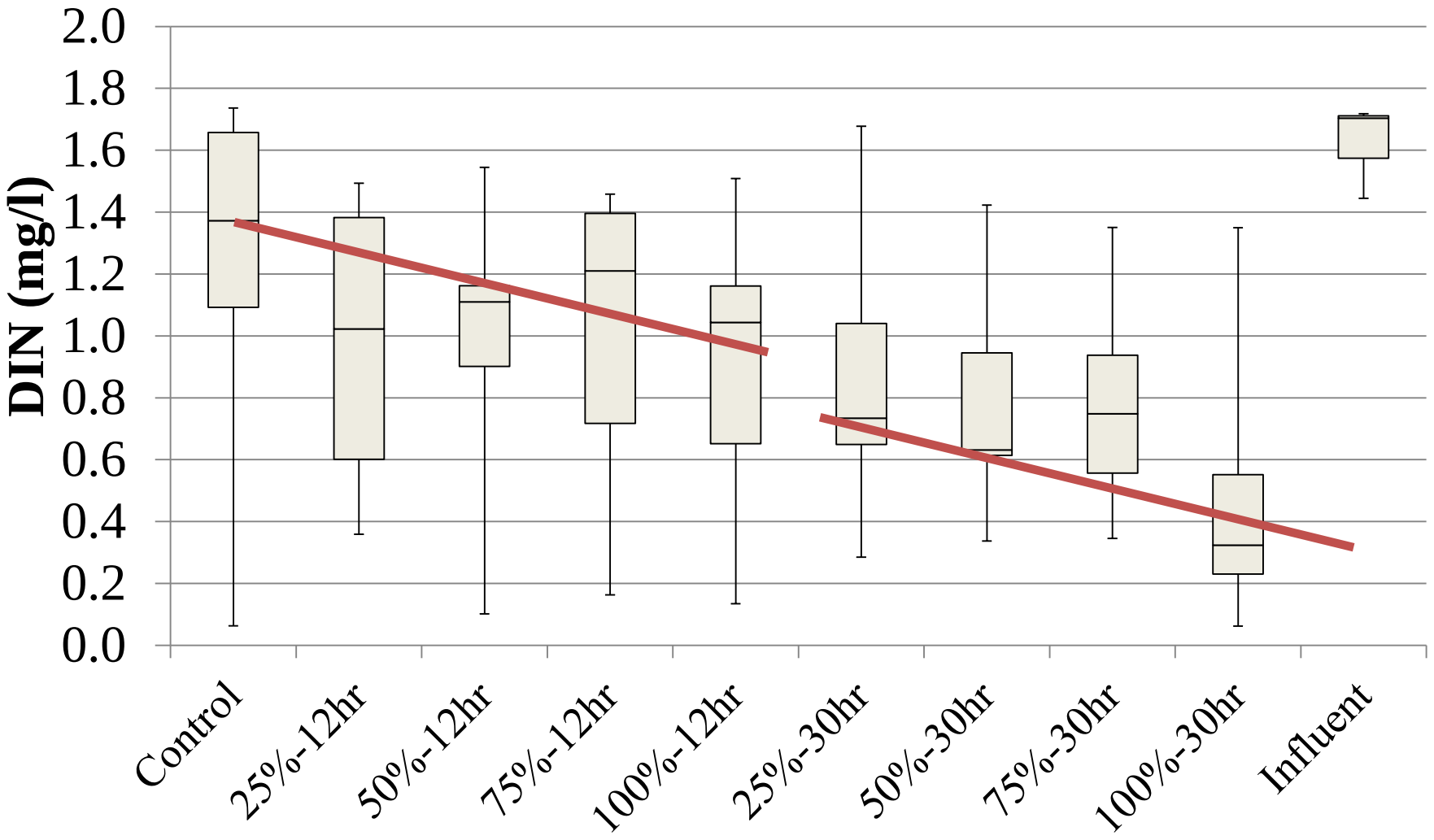


Internal Storage Volume

- Promotes denitrification
  - May need liner at base in high K soils
  - > 1 ft thickness
  - Need to create plug flow through ISV
  - The longer the residence time, the better
    - > 1/3 of WQV
    - > 12 hours

ISV Plumbing

Nitrogen Results



Media Thickness

- Depends on plant root depths:
  - 12 in. for grasses, forbs
  - 18 – 24 in. for shrubs (NHDES min 18”
  - > 30 in. for trees

Do not want roots to clog stone layer and drain pipe below the soil

Vegetation

- Native plants always the best
- Cooperative Extension, USDA, NRCS good sources

- Forest
- Meadow
- Transition
- Ornamental

Plants

- There is little consensus and data WRT bioretention system plantings.
- Most manuals are out of step and out of date
- Planting decisions should be based on owner perceptions of O&M

PB89-128680

BIOLOGICAL REPORT 88(26.1)
MAY 1988

NATIONAL LIST OF PLANT SPECIES THAT OCCUR IN WETLANDS: NORTHEAST (REGION 1)

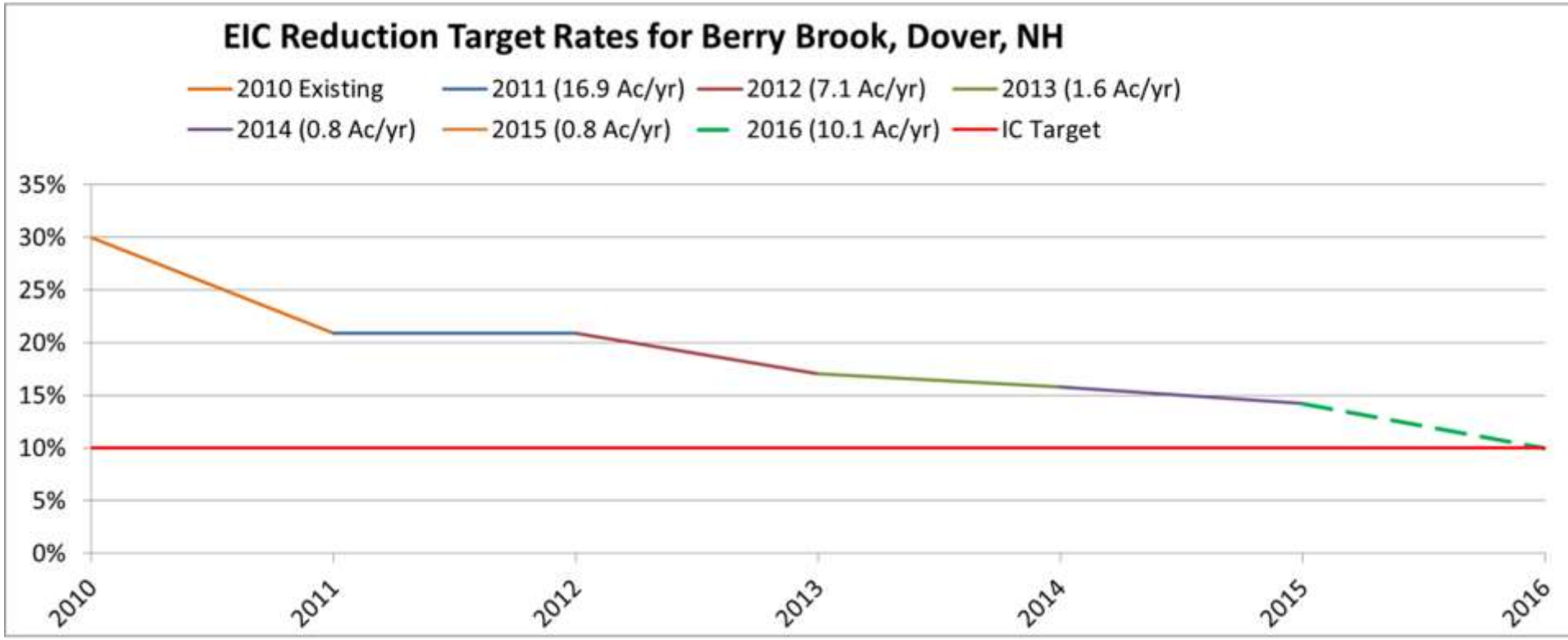
Fish and Wildlife Service

In Cooperation with the National and Regional Interagency Review Panels

U.S. Department of the Interior

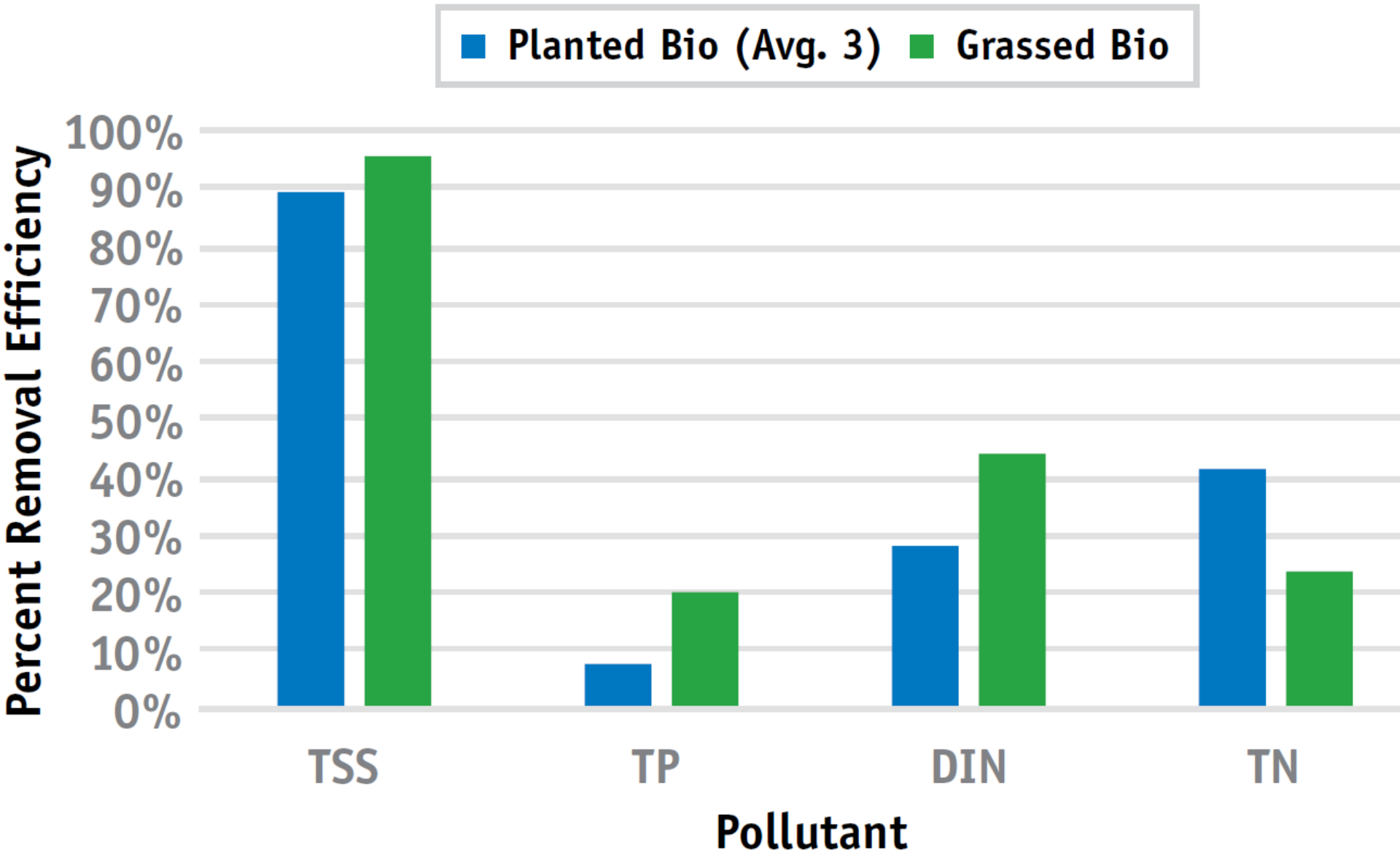
REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

Berry Brook

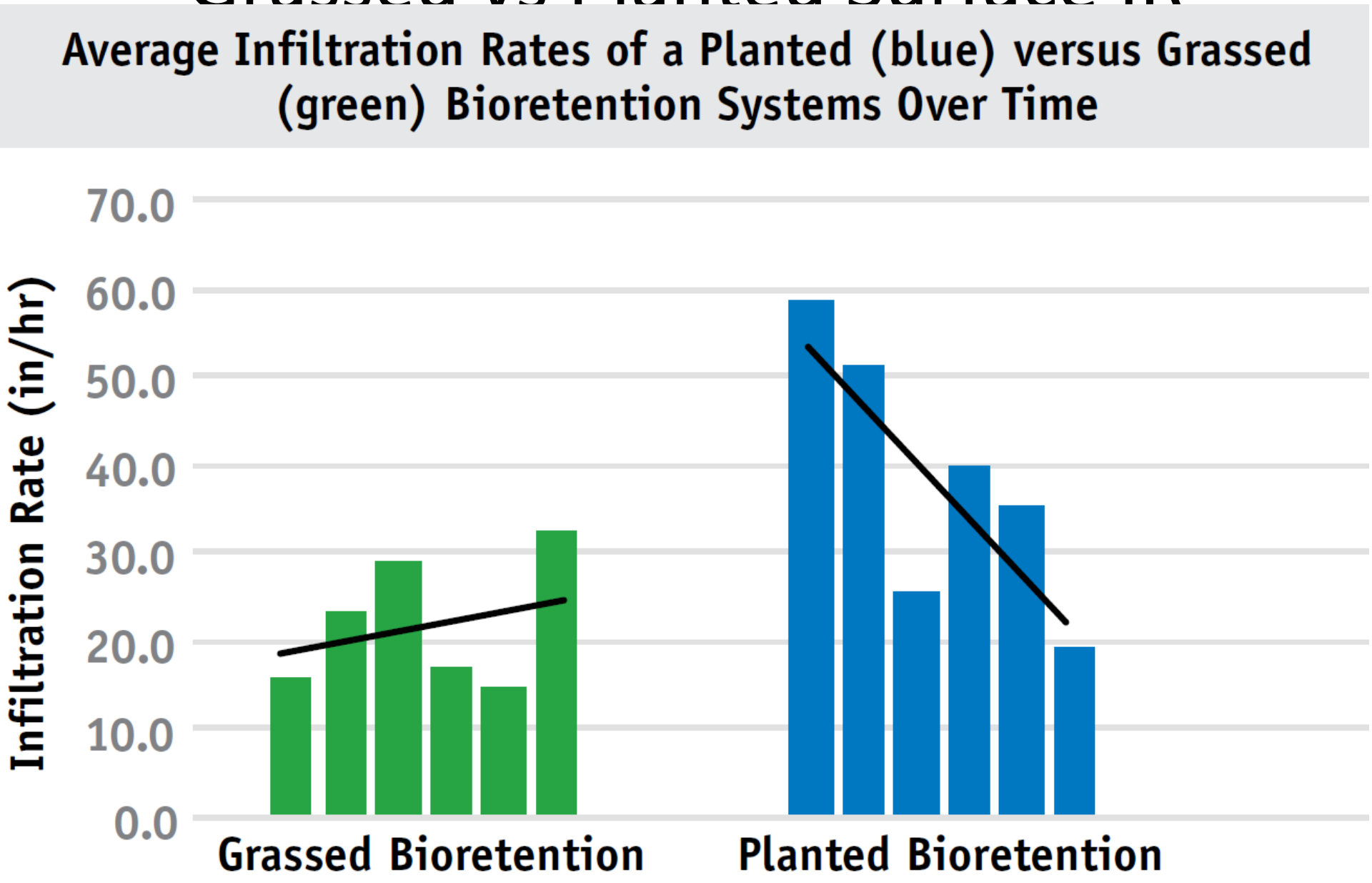

EIC Reduction Target Rates for Berry Brook, Dover, NH
2010 Existing
2011 (16.9 Ac/yr)
2012 (7.1 Ac/yr)
2013 (1.6 Ac/yr)
2014 (0.8 Ac/yr)
2015 (0.8 Ac/yr)
2016 (10.1 Ac/yr)
IC Target
35%
30%
25%
20%
15%
10%
5%
0%
2010
2011
2012
2013
2014
2015
2016

NDP

Comparison of Pollutant Removal Efficiency
Planted vs Grassed Bioretention



Grassed vs Planted Surface IR



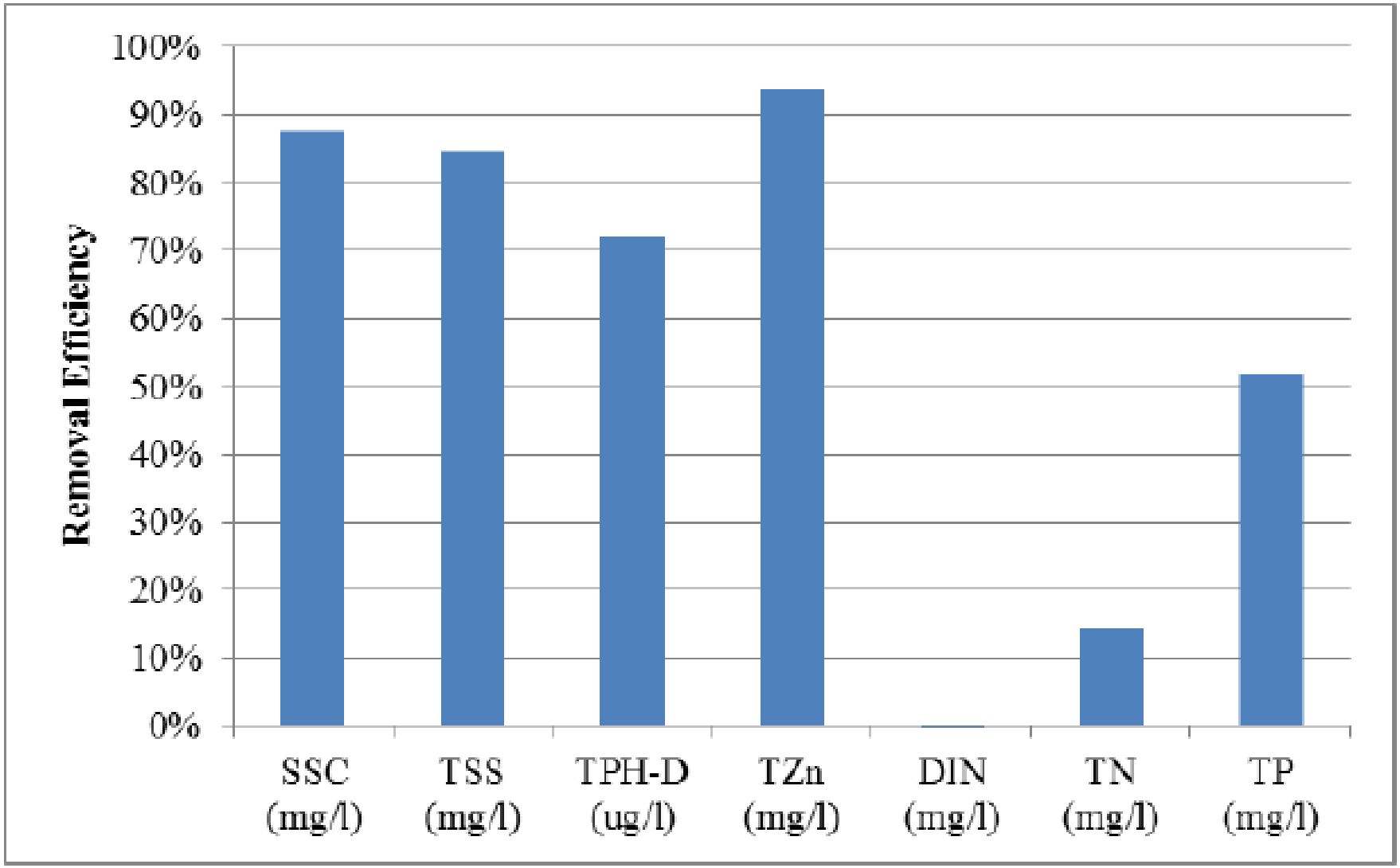
Some Pitfalls of Including Habitat in BMP Designs. Any Questions?

Outstanding Civil Engineering Achievement Award, 2010

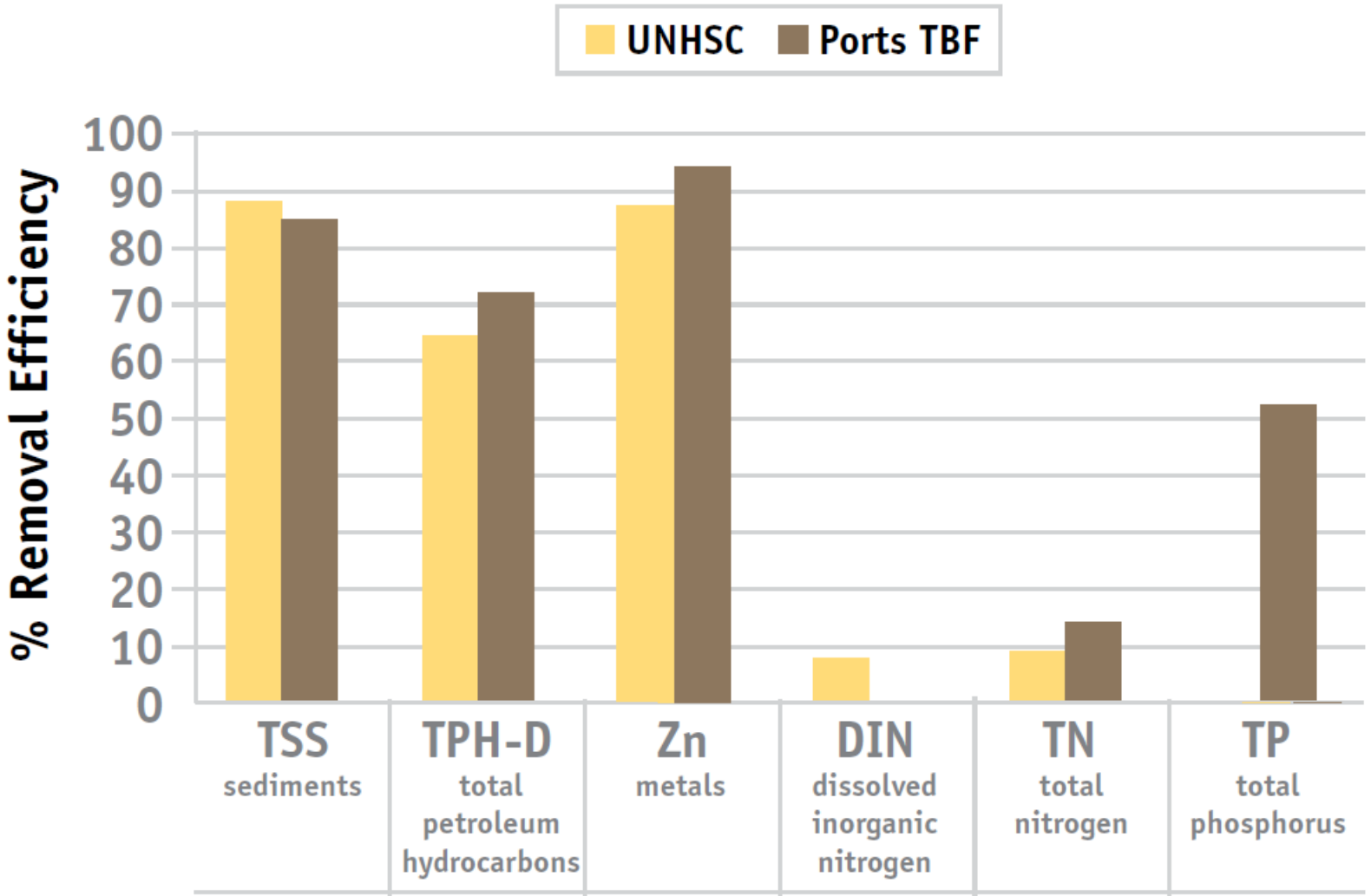
American Society of Civil Engineers, NH Section

Transformation of State Street, Portsmouth, NH. Complete reconstruction of utilities, including wastewater/stormwater separation and stormwater treatment, with construction of pedestrian- and business-friendly streetscape.

System Performance



TREE FILTER PERFORMANCE



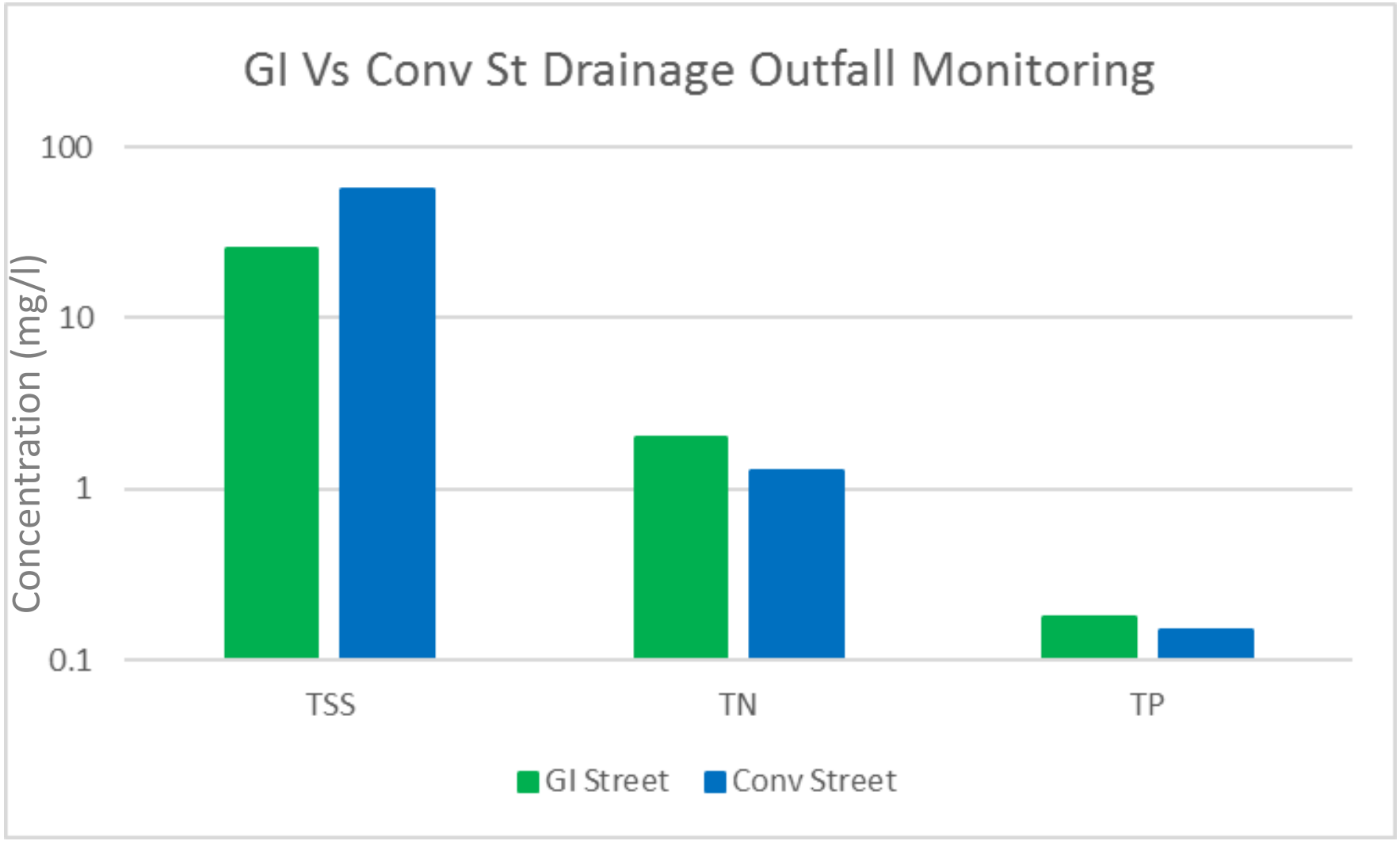
Median Annual Influent Event Mean Concentrations (EMC) in mg/L

UNHSC	31	631	0.04	0.2	1.3	0.07
Ports TBF	39	520	0.10	0.2	1.5	0.21

What is the impact seven years later?

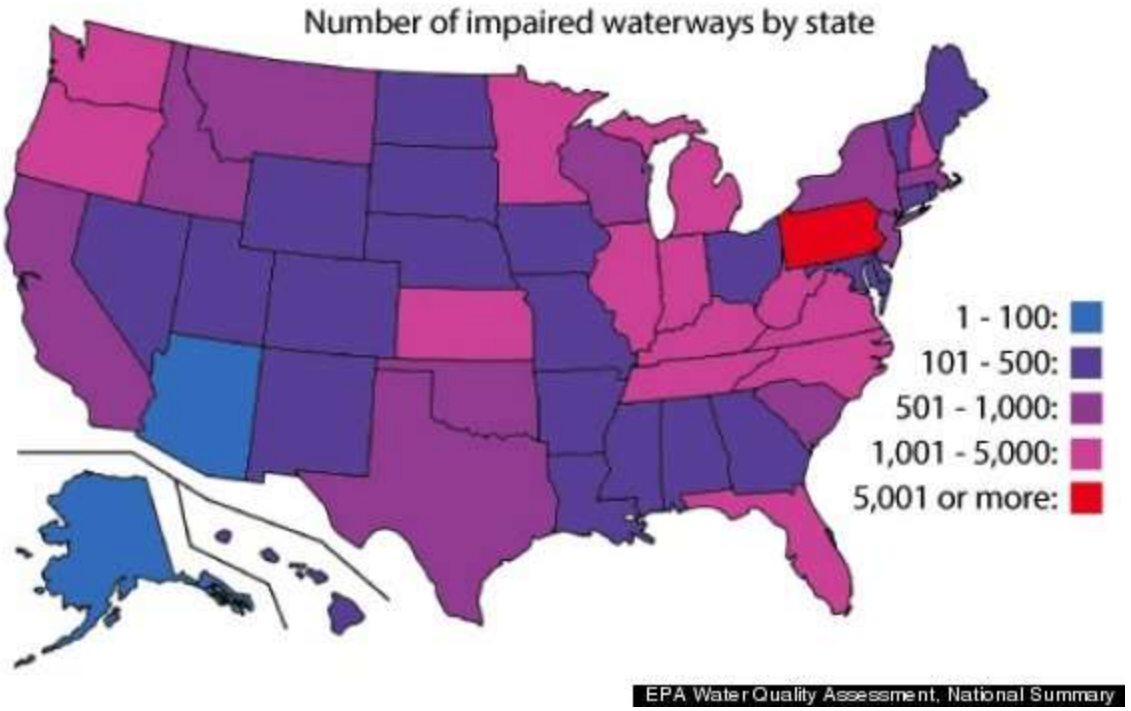
Drainage Area	Area (sf)	Area (ac)	IC (ac)	%IC
State Street	682,531	15.7	13.4	85%
Daniel Street	106,374	2.4	1.8	74%

Maintenance Basics




Brian

Regulatory


Number of impaired waterways by state
1 - 100:
101 - 500:
501 - 1,000:
1,001 - 5,000:
5,001 or more:
EPA Water Quality Assessment, National Summary

Regulatory – up-to-date code

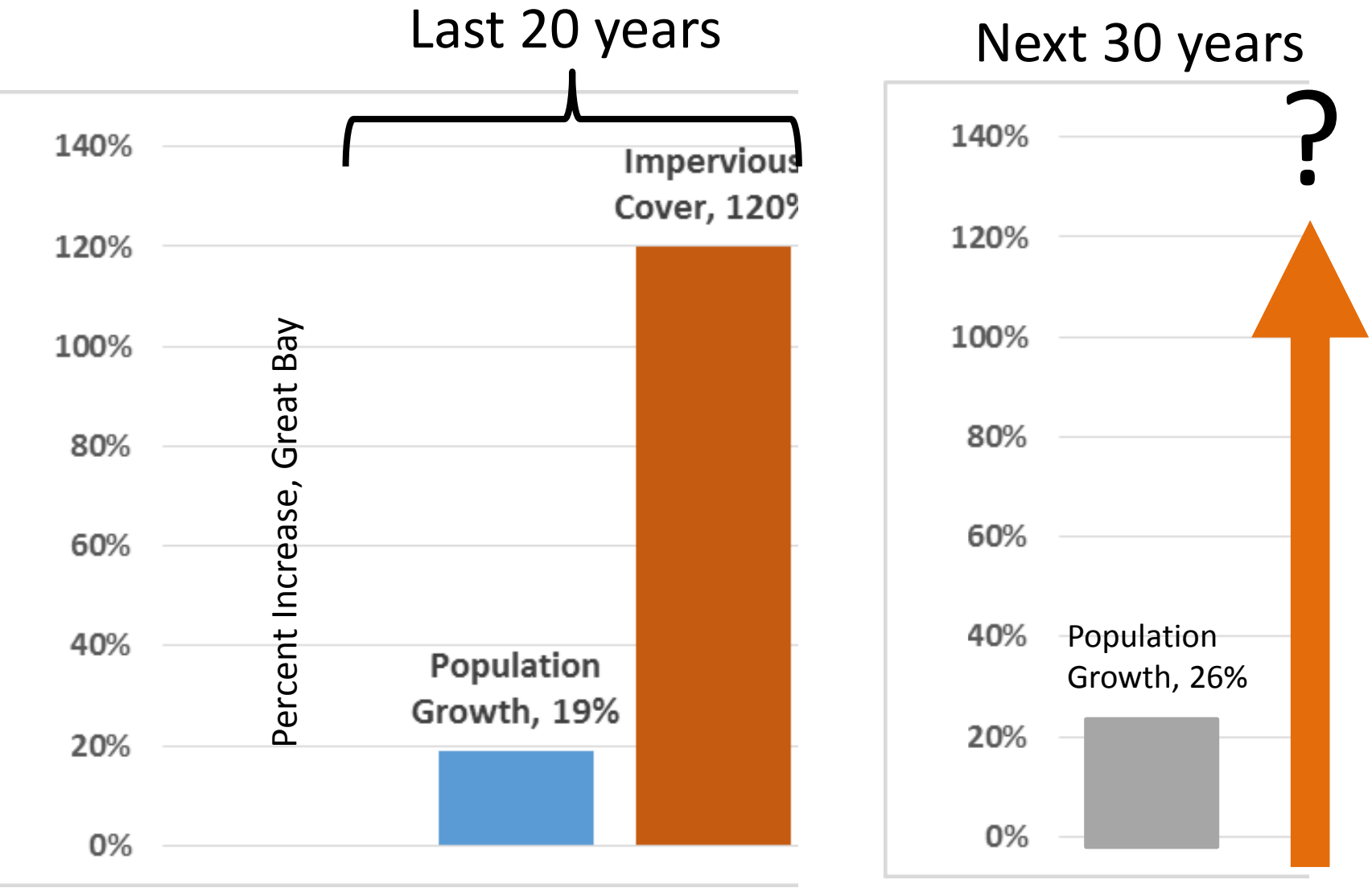
2017 Model Regulations

MODEL STORMWATER STANDARDS FOR COASTAL WATERSHED COMMUNITIES

Prepared by the University of New Hampshire Stormwater Center and
The Rockingham Planning Commission
December 2012

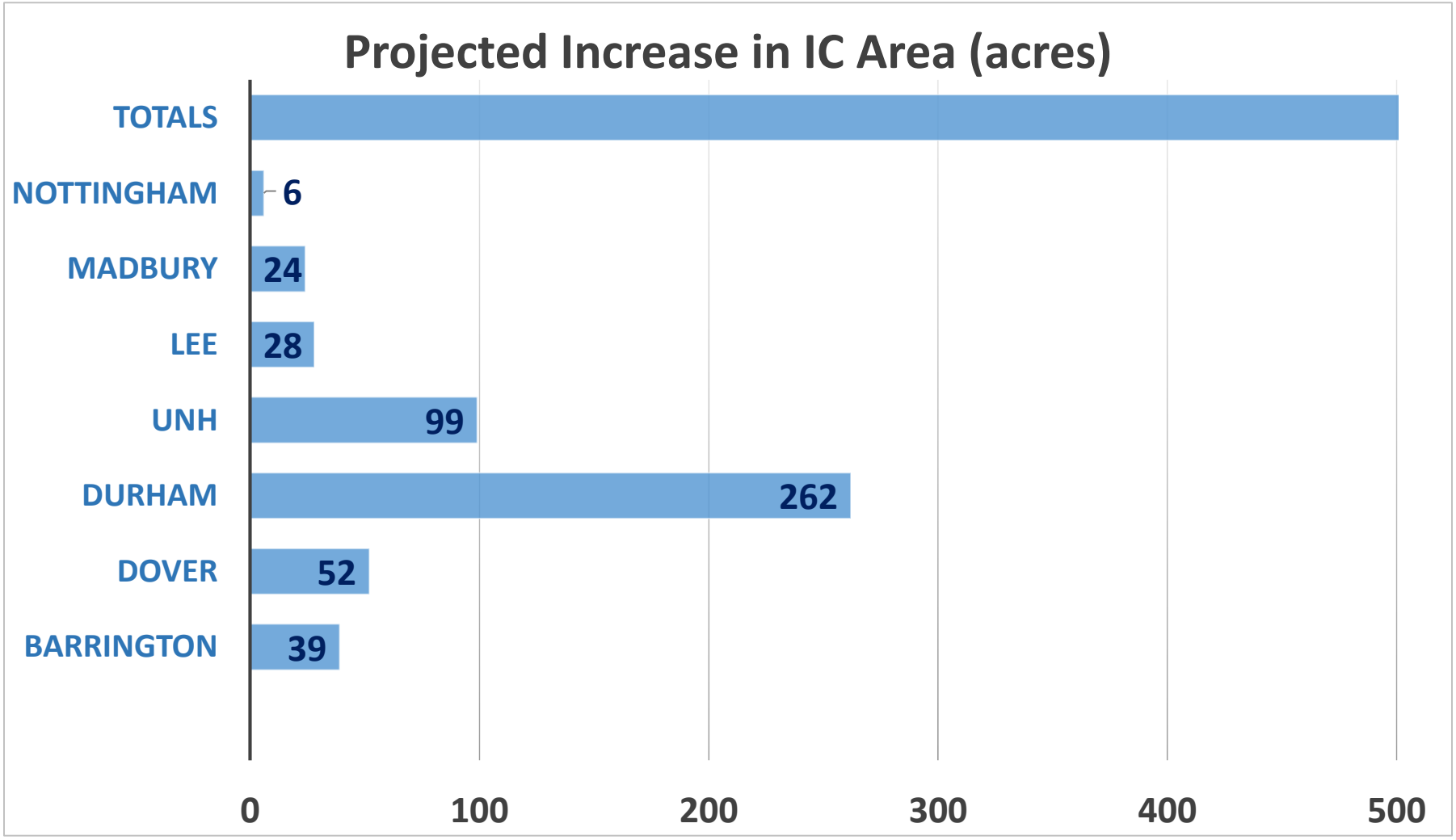
This project was funded under the Coastal Zone Management Act by NOAA's Office of Ocean and Coastal Resource Management in conjunction with the New Hampshire Coastal Program.

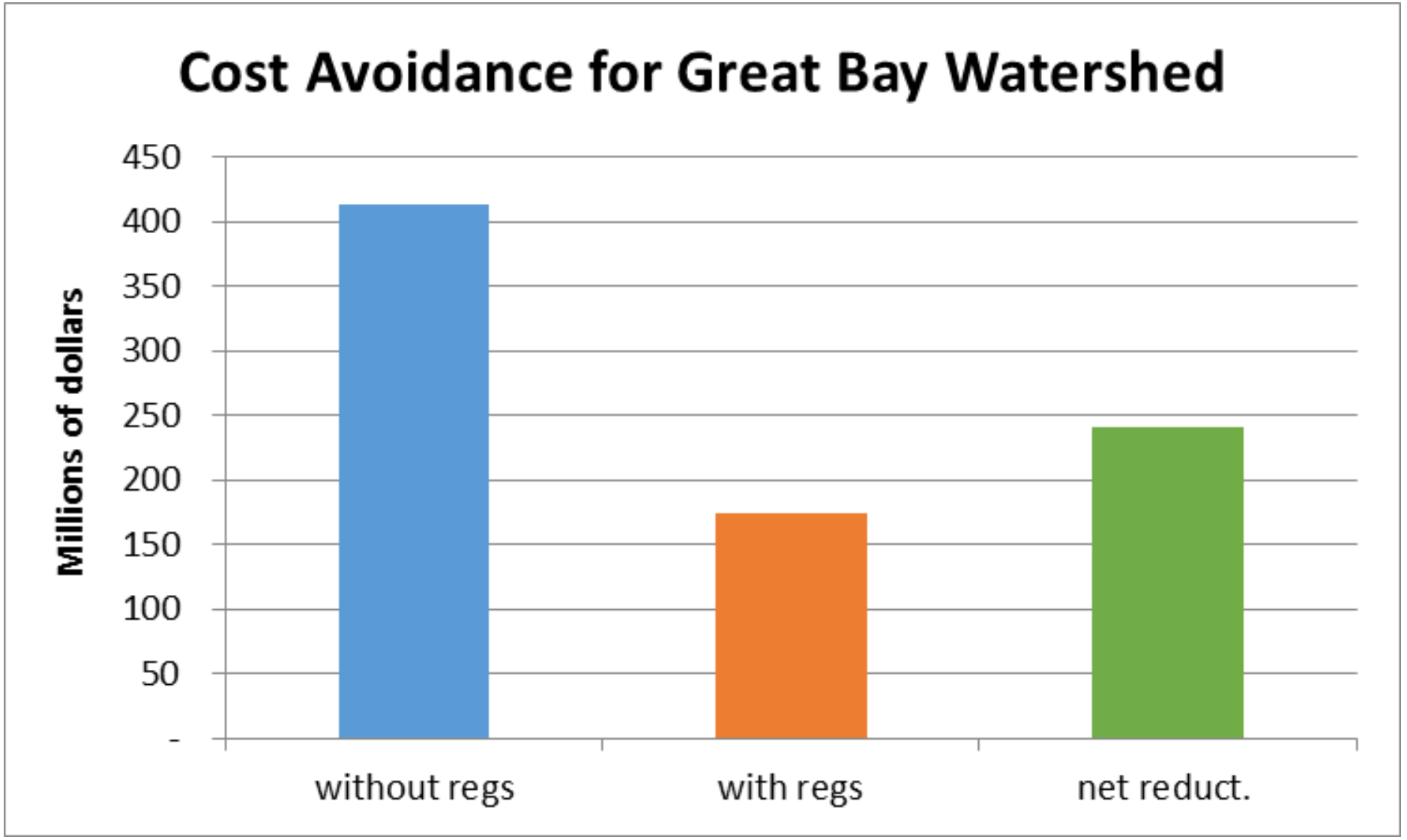
Population Growth & Quality Problem



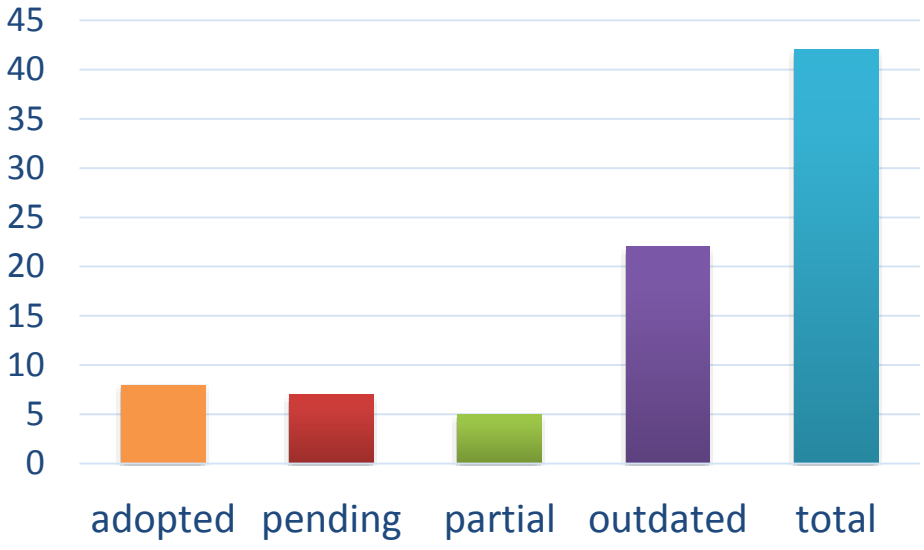
From 1990 to 2010 (Source: US Census; UNH earth systems research center; PREP; 2010-2040 Projections, UNHSC)

Projected Future IC Area by 2040

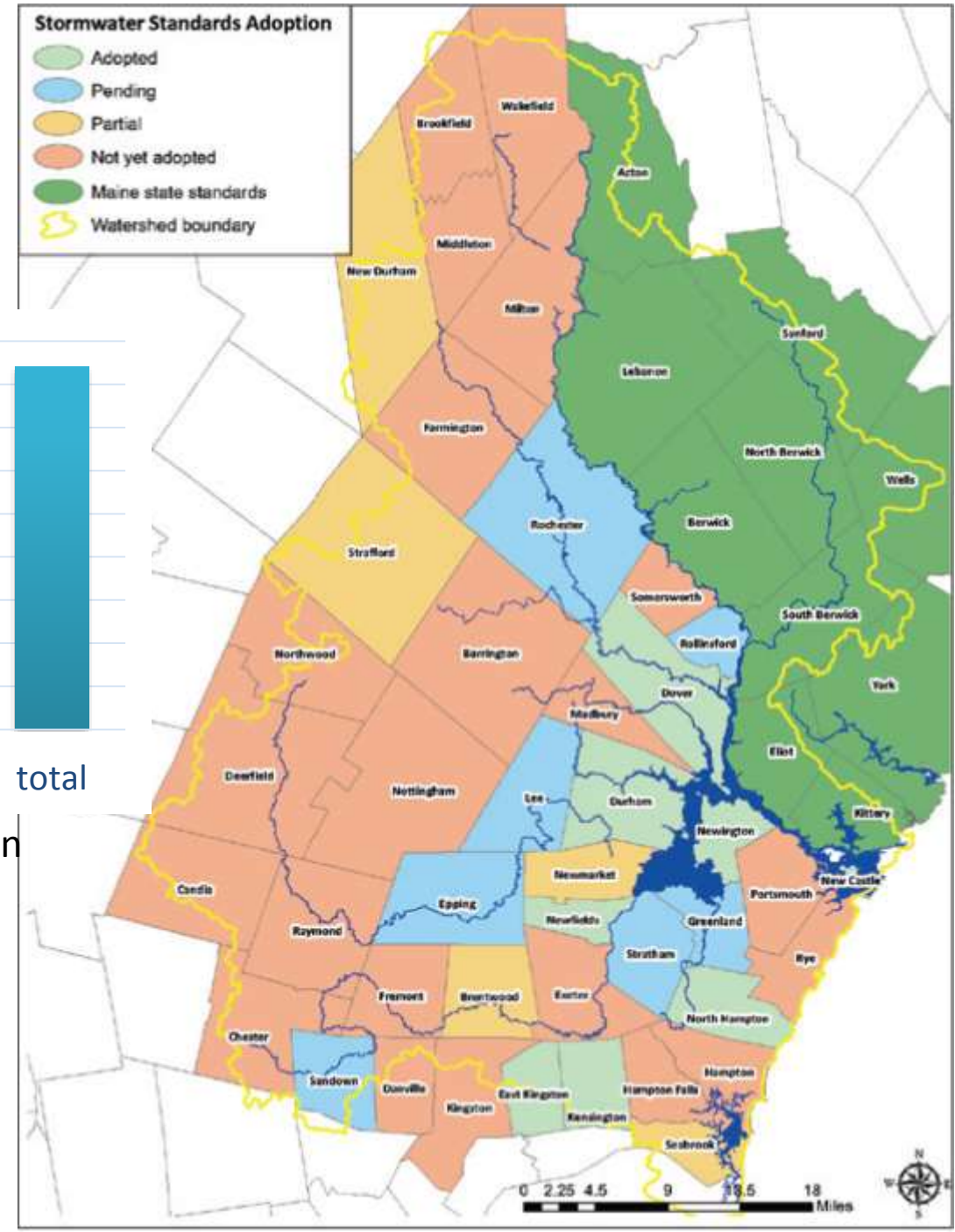




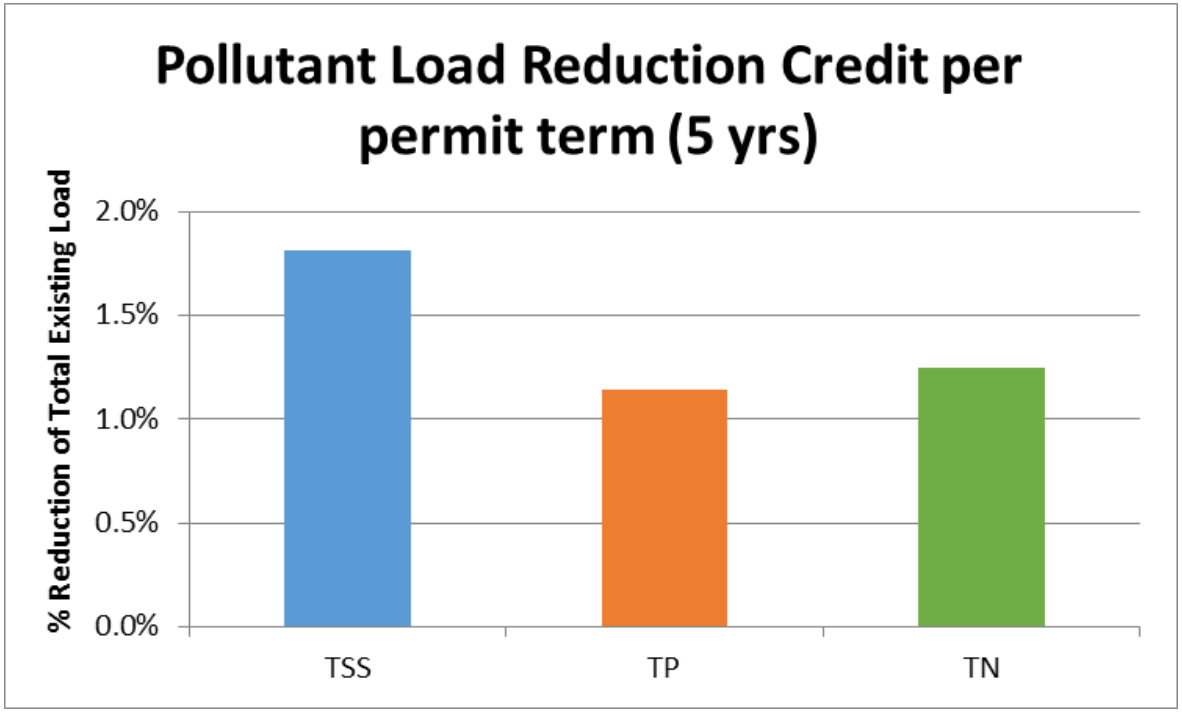
Assumes Oyster River Watershed Ratios are consistent throughout the GB



GB Community SW Standards Adoption

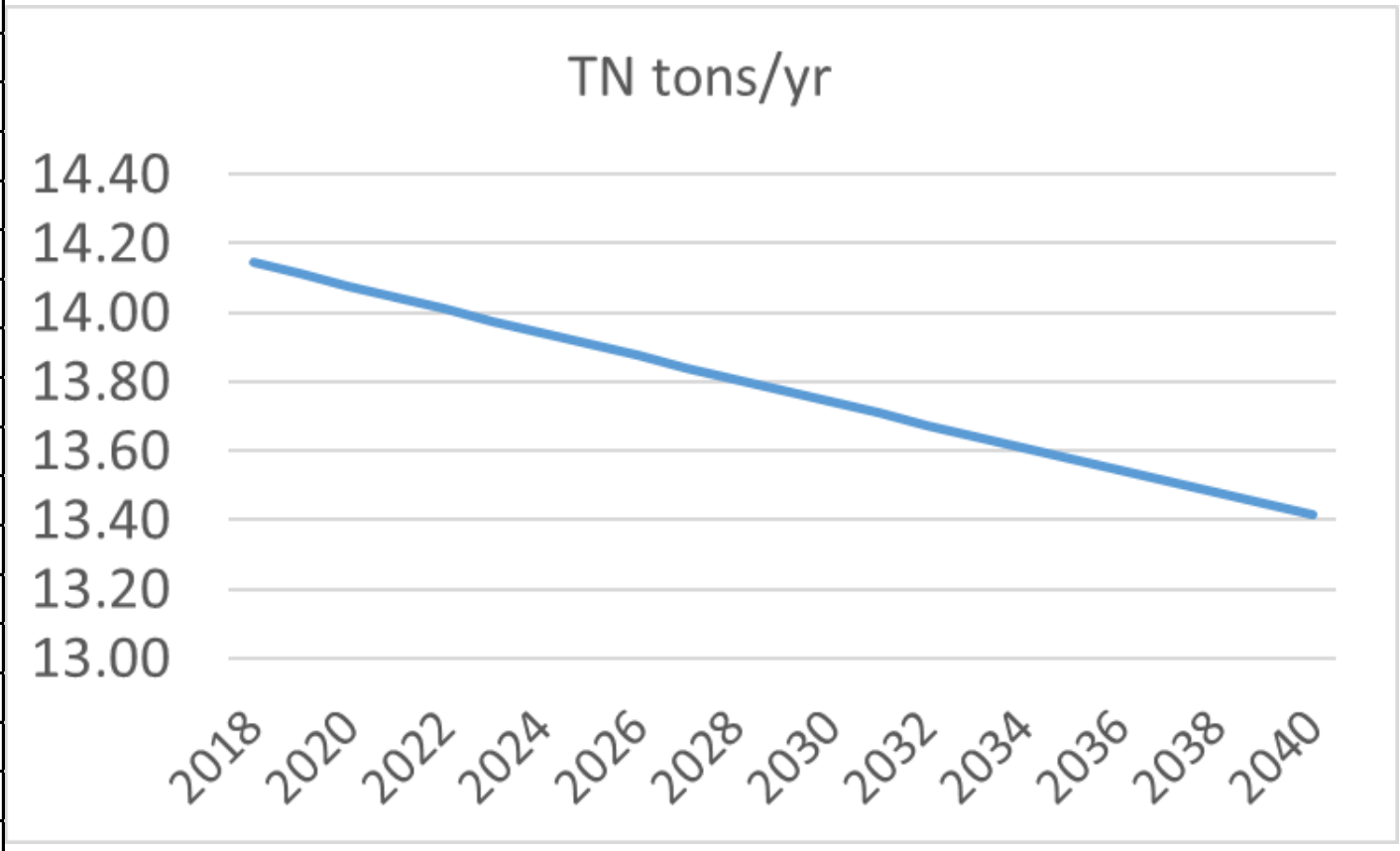


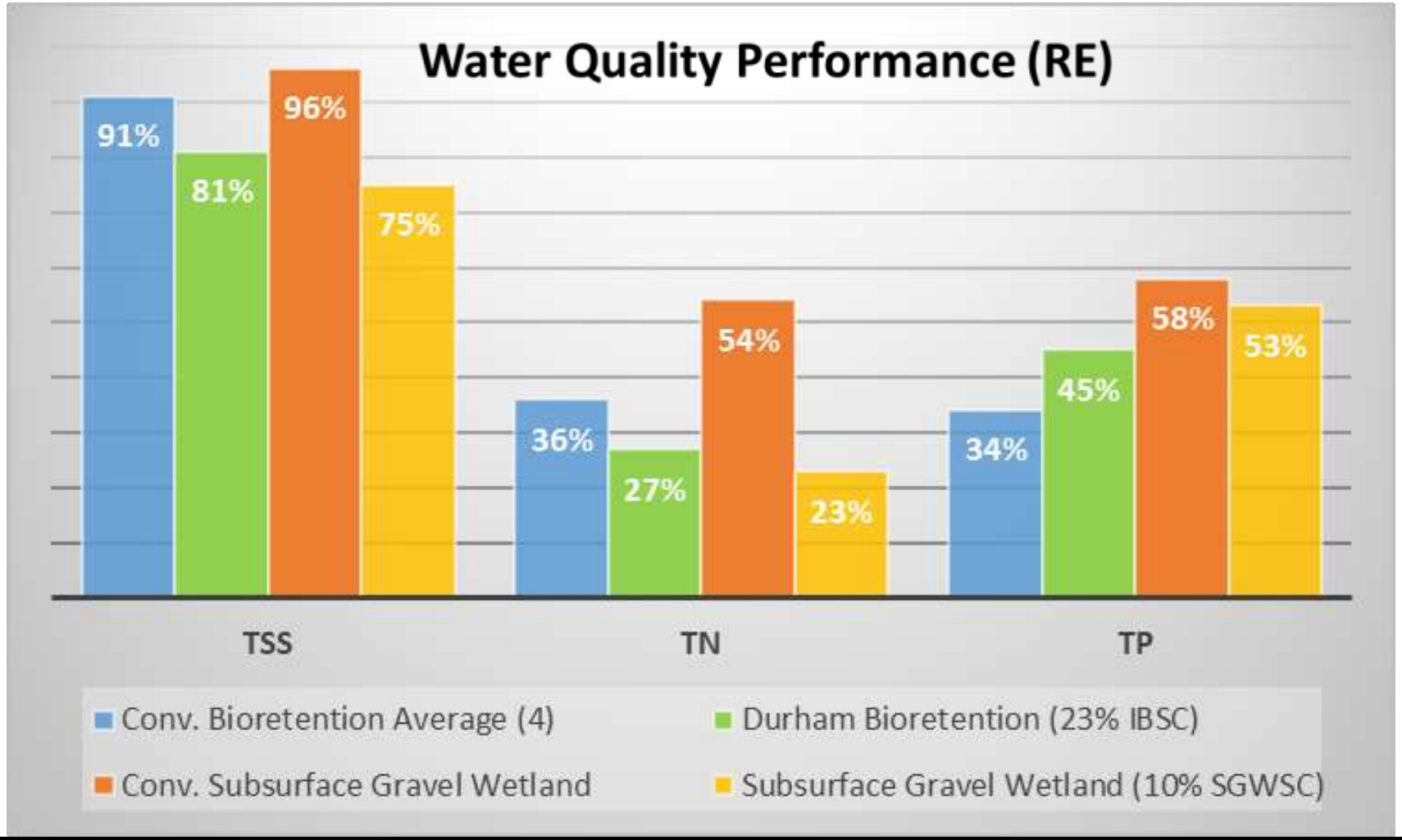
Potential Reduction Credits



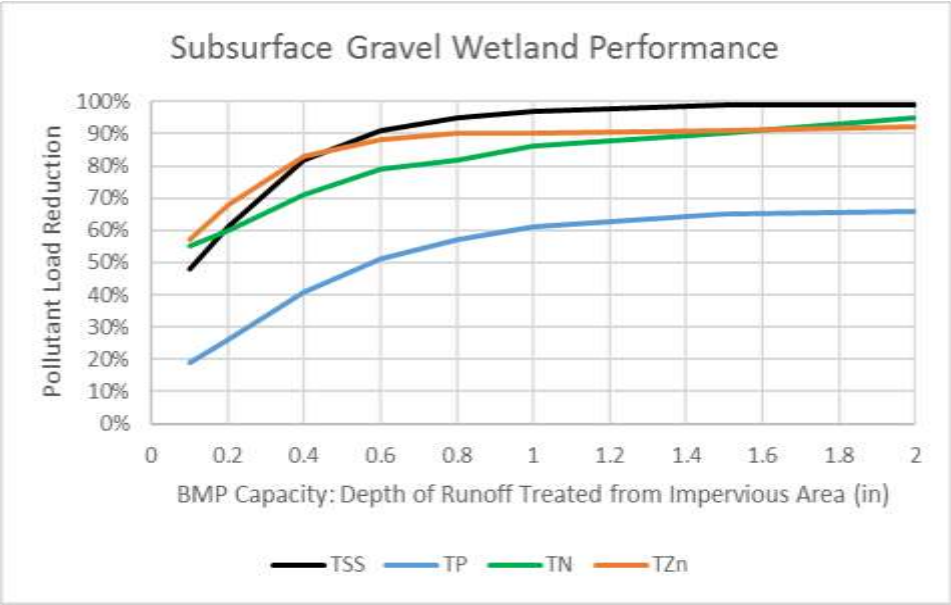
14.18 tons/yr =

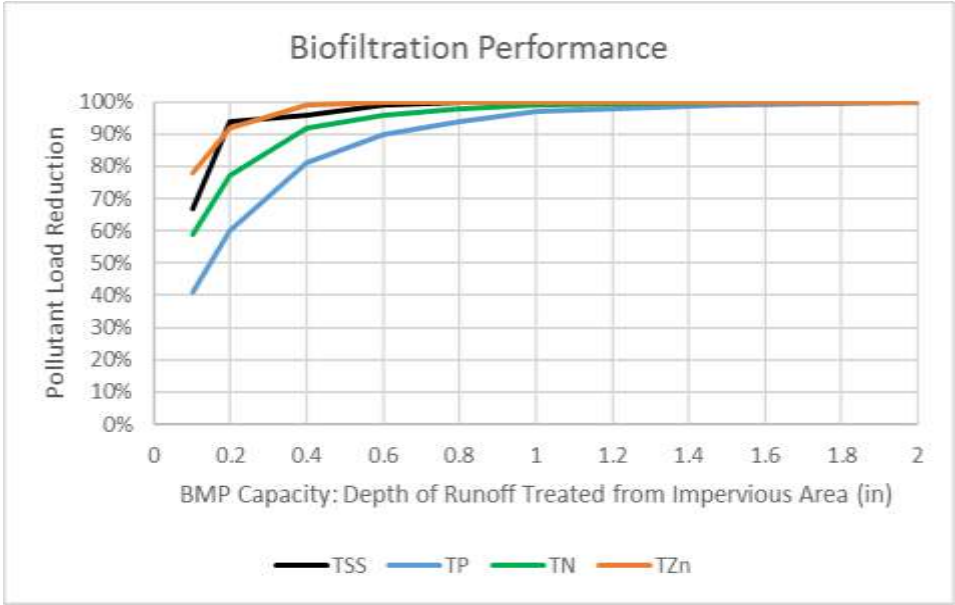
	TN tons/yr	% RE
Baseline	14.18	0.012
2018	14.15	0.034
2019	14.11	0.034
2020	14.08	0.034
2021	14.04	0.034
2022	14.01	0.034
2023	13.98	0.034
2024	13.94	0.034
2025	13.91	0.034
2026	13.88	0.034
2027	13.84	0.034
2028	13.81	0.033
2029	13.78	0.033
2030	13.74	0.033
2031	13.71	0.033
2032	13.68	0.033
2033	13.64	0.033
2034	13.61	0.033
2035	13.58	0.033
2036	13.54	0.033
2037	13.51	0.033
2038	13.48	0.032
2039	13.45	0.032
2040	13.41	0.032





System	TSS	TN	TP
Conv. Bioretention Average (4)	91%	36%	34%
Durham Bioretention (23% IBSC)	81%	27%	45%
Conv. Subsurface Gravel Wetland	96%	54%	58%
Subsurface Gravel Wetland (10% SGWSC)	75%	23%	53%





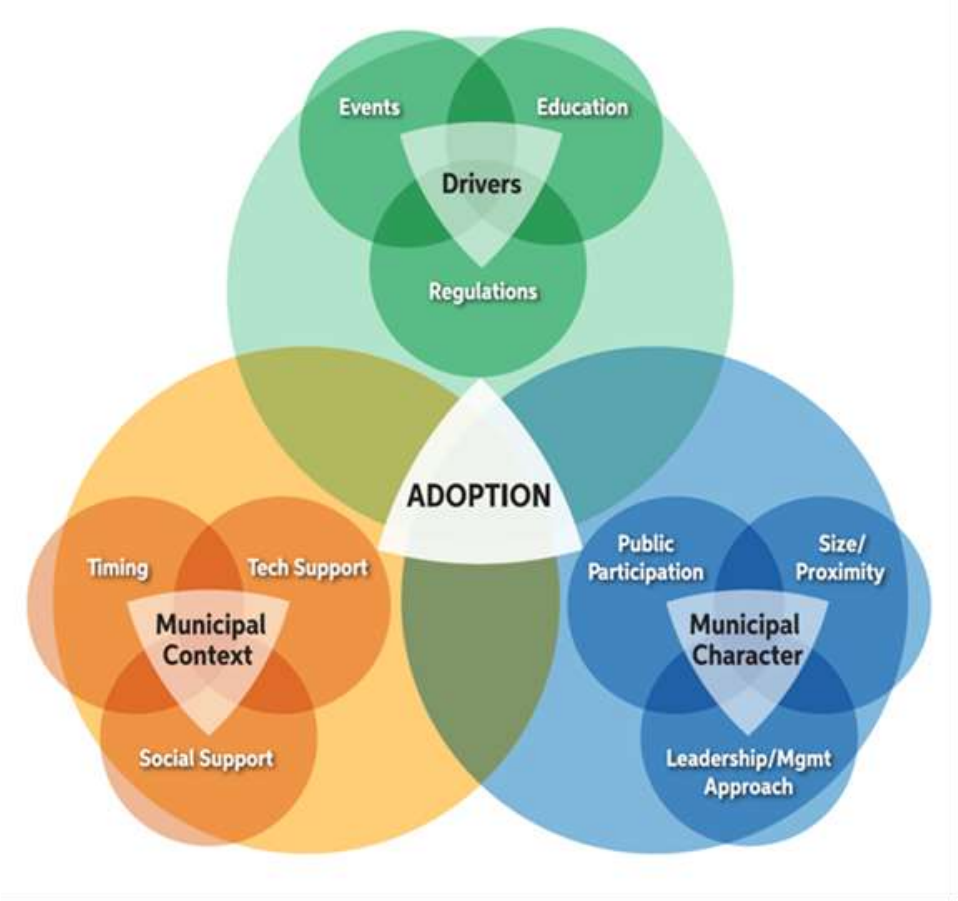
physical storage capacity - runoff depth from IA (in)

Analyte	Depth txt	Modeled RE	Measured RE
TSS	0.1	48	75
TZn	0.1	57	75
TN	0.1	55	23
TP	0.1	19	53

Analyte	Depth txt	Modeled RE	Measured RE
TSS	0.23	70	81
TZn	0.23	88	86
TN	0.23	60	27
TP	0.23	35	45

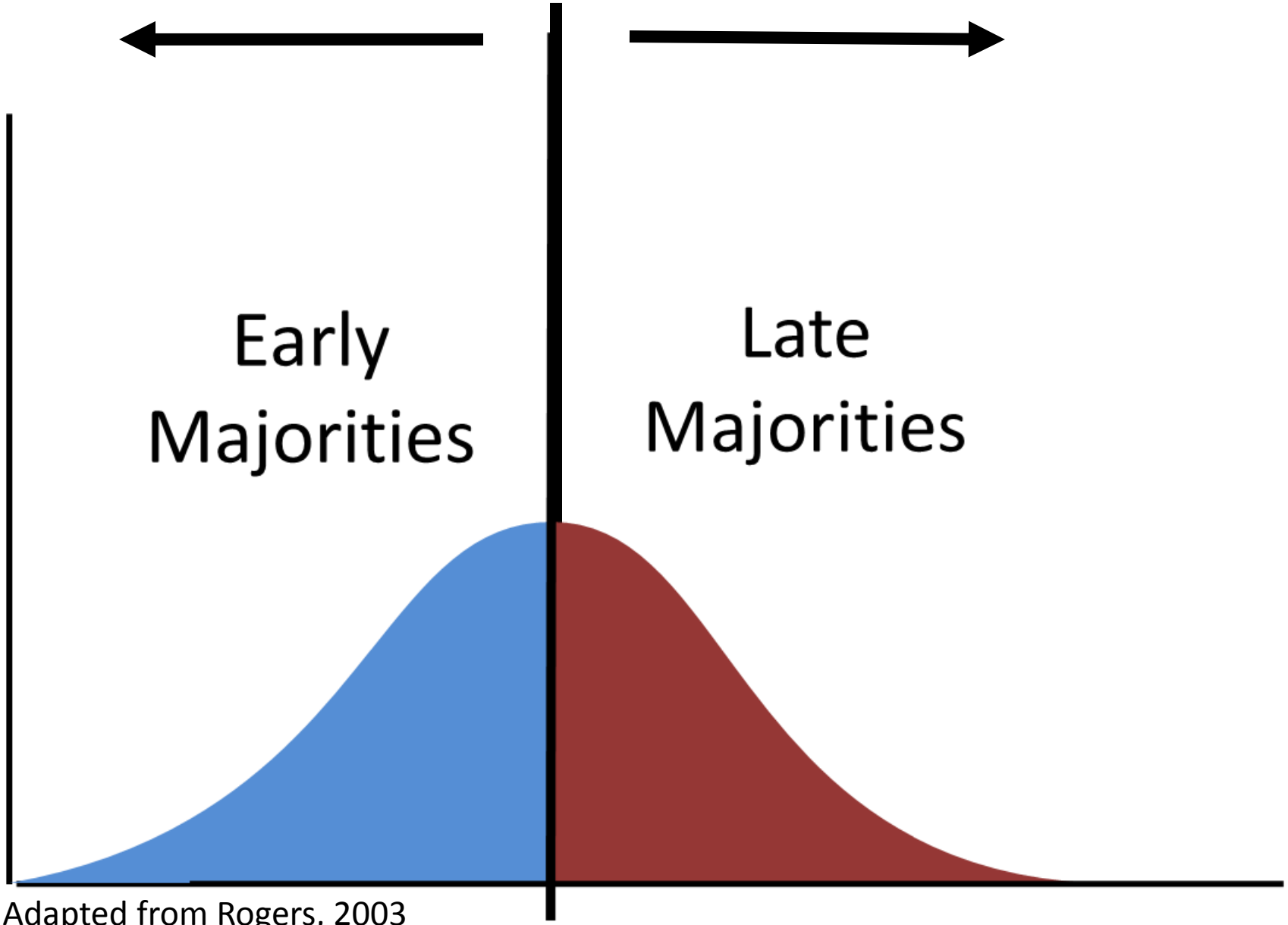
Social

Conceptual Model Factors Influencing Adoption



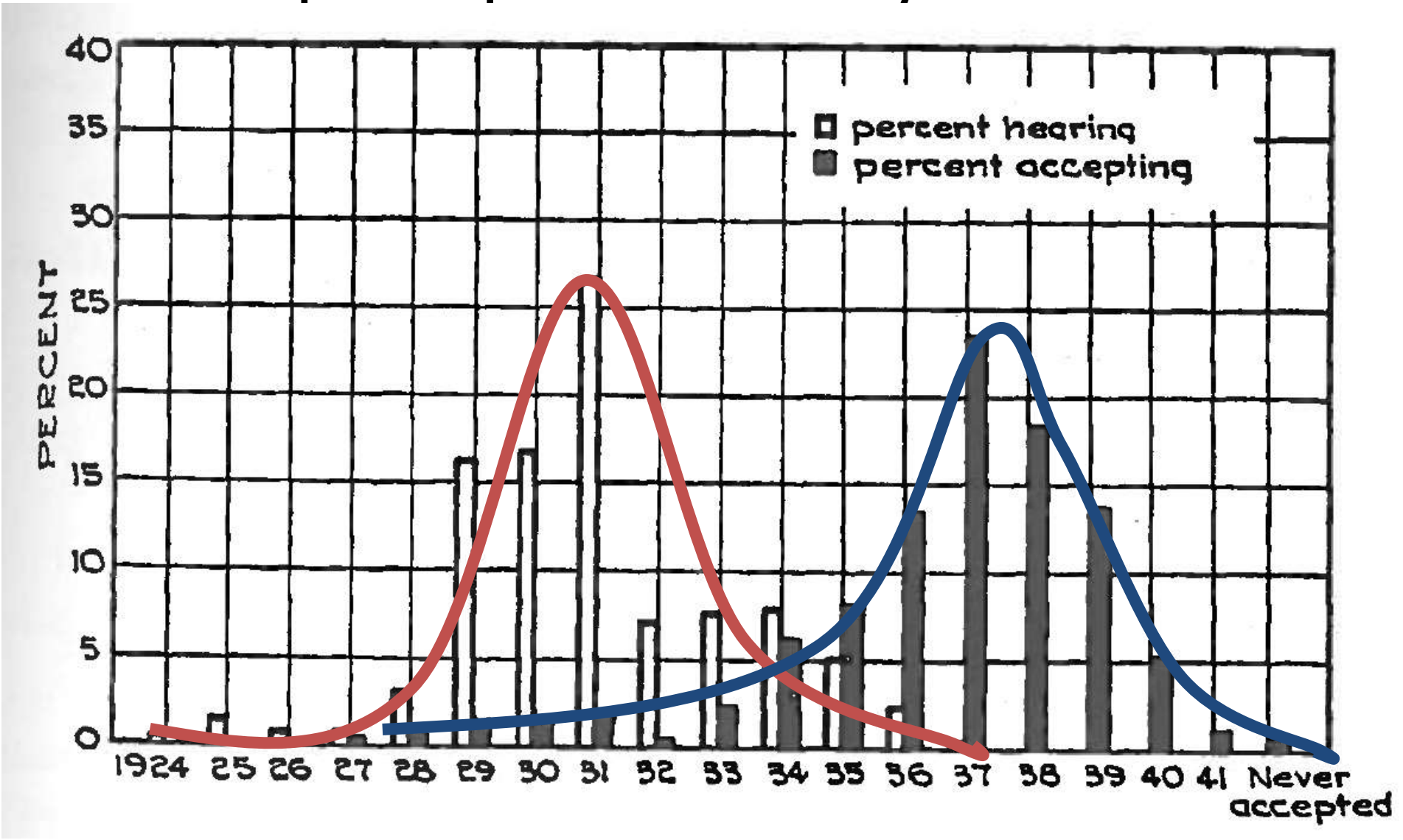
Diffusion of Innovation

- Diffusion of innovation is the process by which an **innovation** is communicated through certain channels over time among the members of a social system (Rogers, 2003)



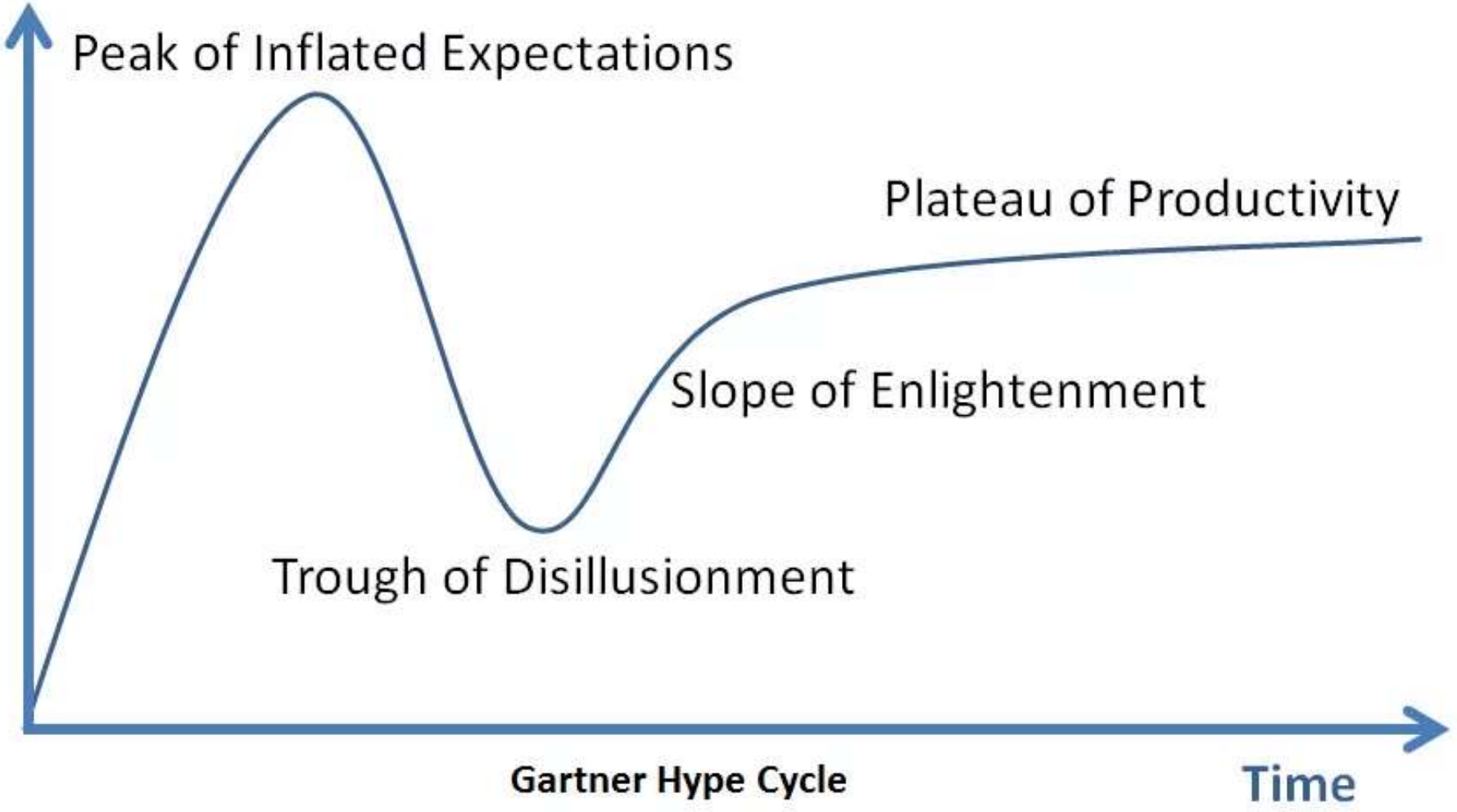
Adapted from Rogers, 2003

Results from Ryan and Gross on farmer adoption patterns of hybrid corn.

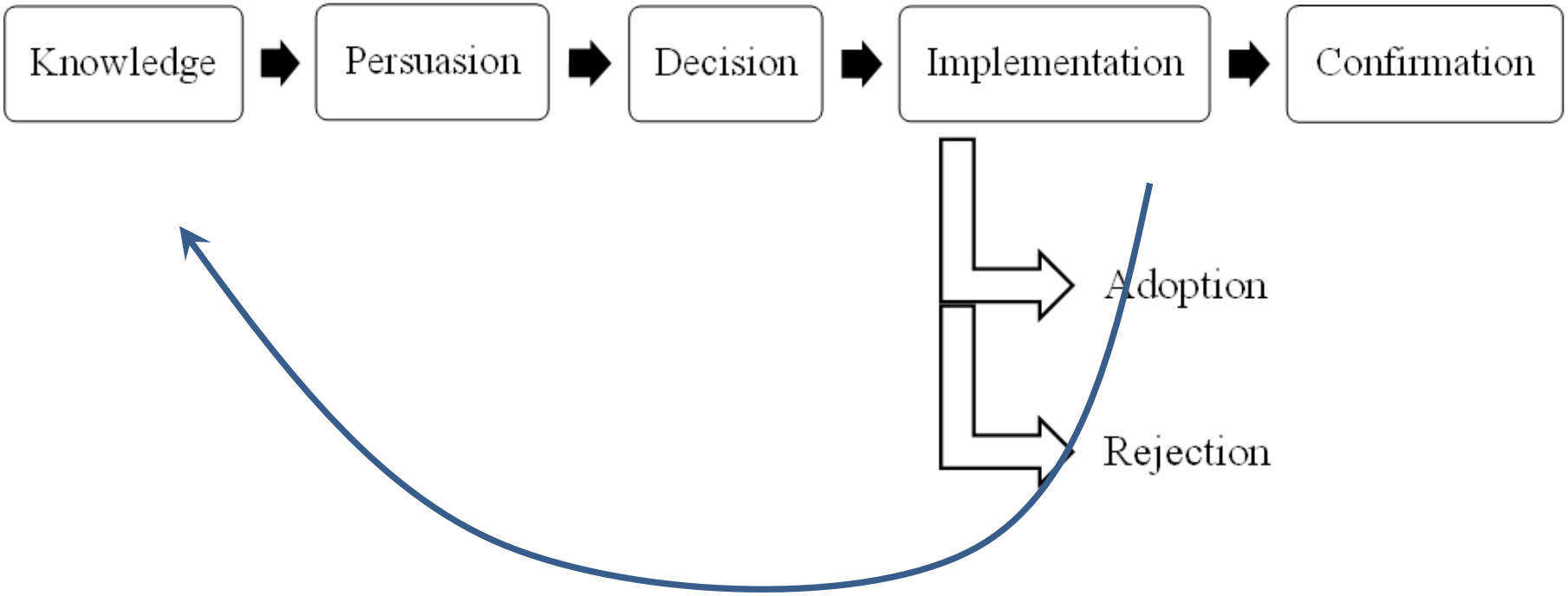


Source: Ryan & Gross (1943), "The Diffusion of Hybrid Seed Corn in Two Iowa Communities," *Rural Sociology 8* (March): 15.

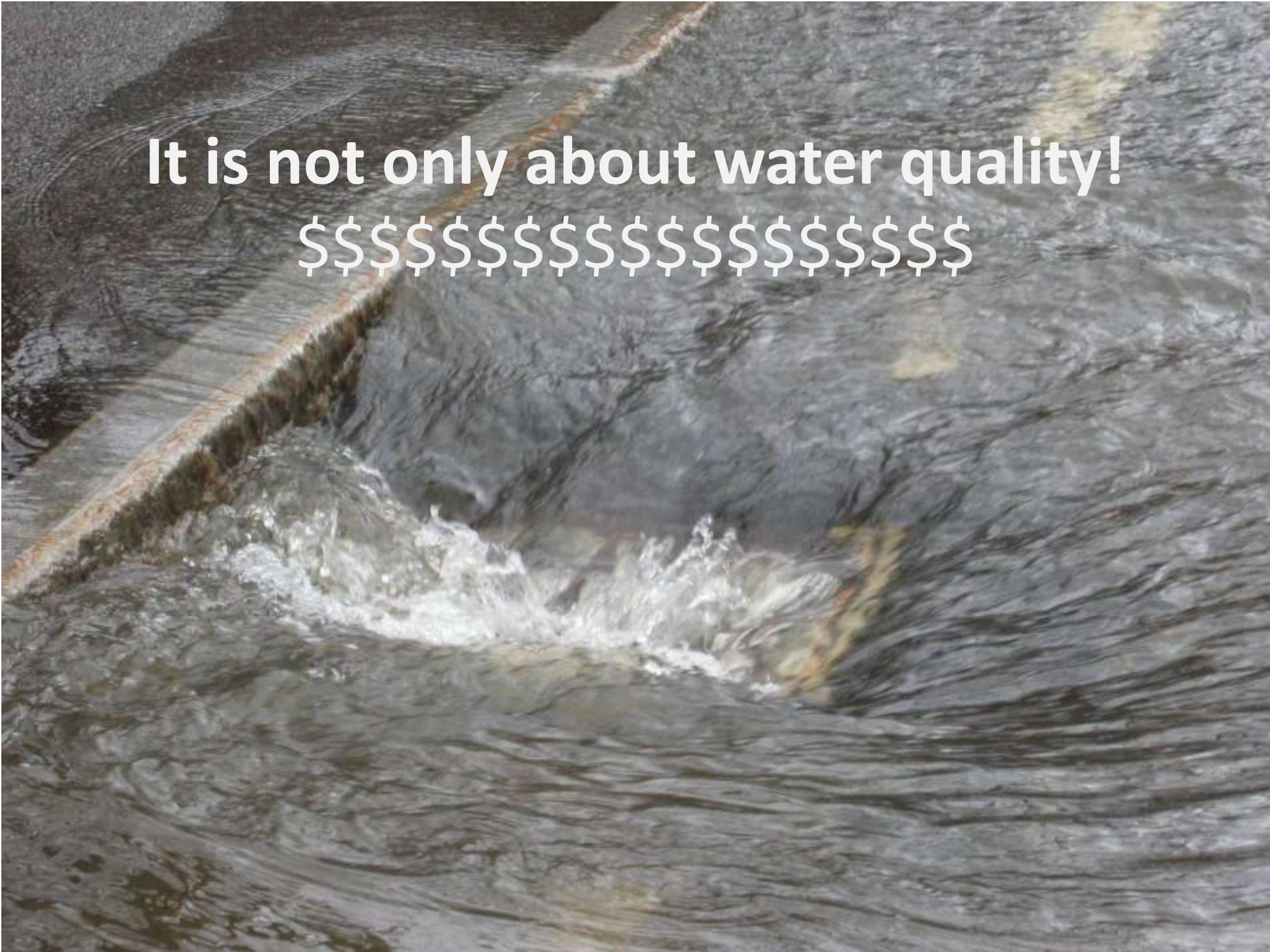
Gartner-Hype – how disruptive technologies adapt over time



Innovation Decision Process



Ability to reinvent to reflect local needs and foster ownership


It is not only about water quality!
$$$$$$$$$$$$$$$$$$$$

Priorities and Water Quality

Advocates Fear Scott Administration Is Weakening Landmark Water Quality Law

By PETER HIRSCHFELD • JAN 17, 2018

PROGRAM
VPR News

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The Vermont Clean Water Act will hold more than 1,000 properties across the state to stricter stormwater standards, but environmental advocates say the Scott administration is trying to undermine some key provisions.

PETER HIRSCHFELD / VPR/FILE

"The study really revealed that the penalty for so-called under-sizing a system was not as great as we believed it would be," Houle says. "It means that there's a lot of benefit for doing what you can where you can how you can."

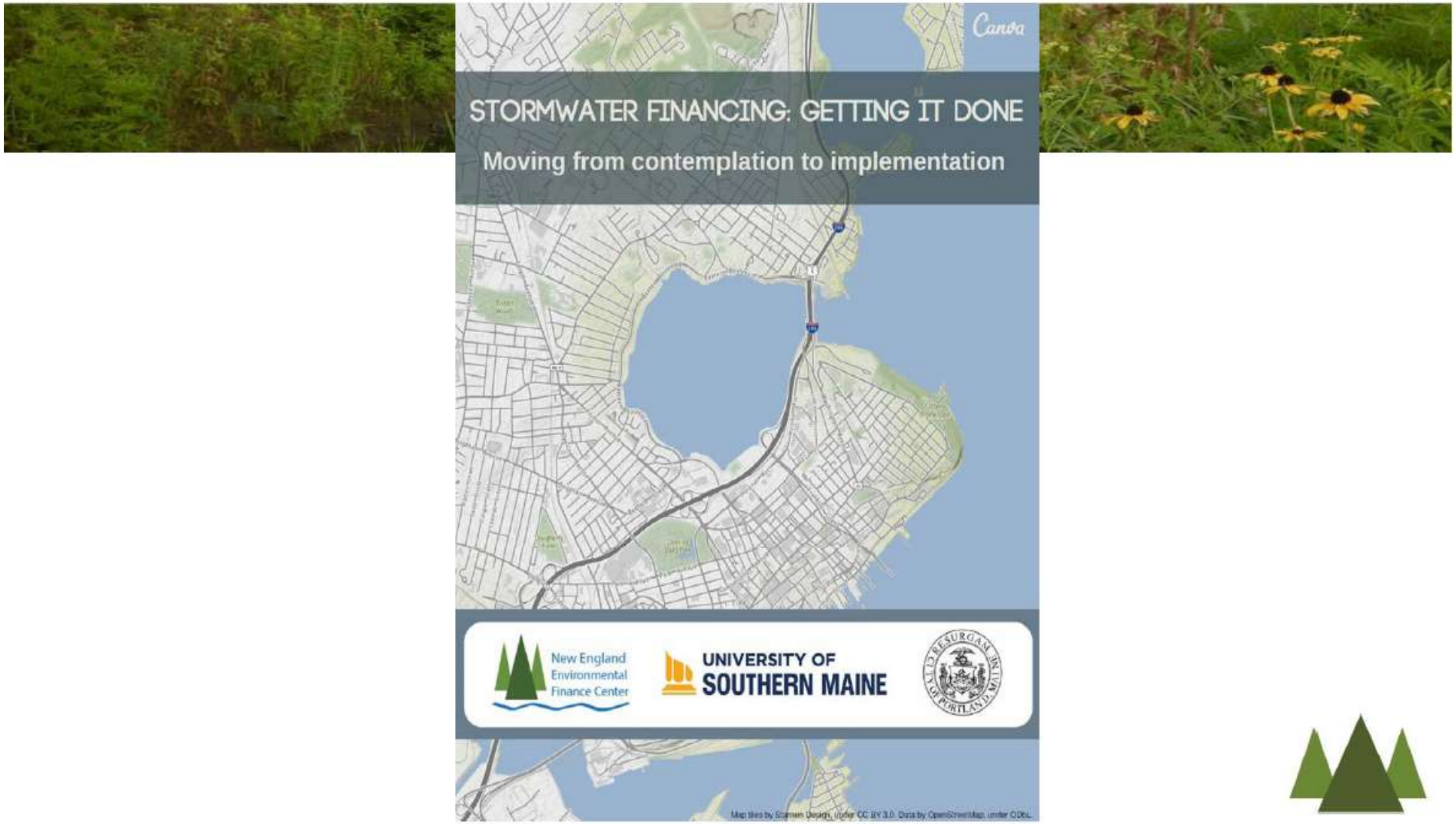
So does that mean Vermont can get away with holding legacy sites to a lower volume standard? Here's how Houle answers that question:

"Managing stormwater is relatively recent science, and the way I look at it is, we can benefit from implementation, whatever that implementation is," Houle says. "I would be less likely to promote one sizing criteria over another, and more likely to say, 'We have a major problem that we've swept under the rug for decades, and it's time that we start to implement. And however you want to get to implementation, I think I'm fine with for now."

Dover, NH

- 2,800 catch basins
- 65 miles of pipe
- 200 outfalls

New England Environmental Finance Center
University of Southern Maine




Questions???